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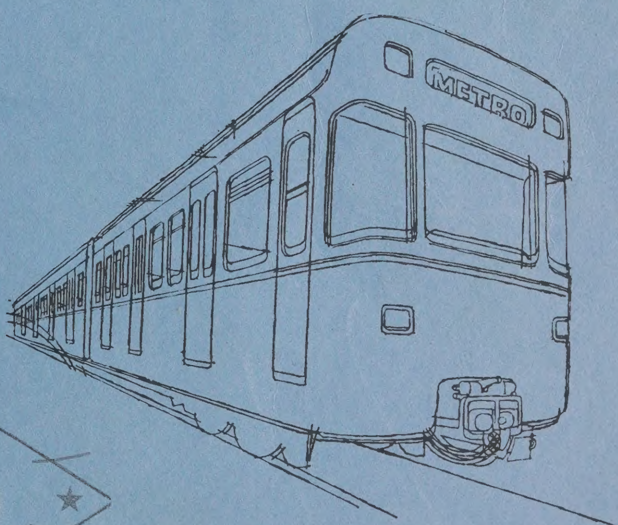
PASSENGER TRANSPORT IN CANADIAN URBAN AREAS



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Canadian Transport Commission

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Preamble

This report is the result of a three month study. Inevitably in this short time, it was not possible to cover all aspects of urban transport and its interaction with other urban activities. Therefore, the nature of this report is a general review with references to additional material and suggestions of areas where additional research is desirable.

The report is intended to complement a recent Canadian report: "Urban Transport in Canada. A Factual and Analytic Review" by D.J. Reynolds of the Central Mortgage and Housing Corporation.

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Introduction

There is a prevalent trend in discussing urban transportation to elaborate on the ever growing problem of too much demand chasing too few facilities and by projecting these demands into the future to predict the eventual development of total chaos. In fact, the situation is now and can be expected to remain always one step below chaos. Urban transportation is an amalgam of individual journeys made by individuals who for all their frailties tend to be flexible. Hence when travel becomes too congested or too tedious, those with the freedom to do so will change their residence, their employment, or their mode of transport to produce a more convenient situation. Thus, there is created an automatic degree of restraint that is a valuable tool in maintaining some degree of mobility at all times and there is every reason to believe that this minimal level of mobility will be maintained, (except of course when bad weather or special events disrupt the normal travel patterns and for a while a city may descend into chaos).

A question that must be asked is whether this minimum level of mobility is adequate. The obvious answer is no, for it is ironic in this era of technological superlatives that twice every work-day, millions of people must suffer inconvenience and congestion at speeds their forefathers could exceed in a horse and cart. However, the alternatives available in improving urban mobility are not always palatable either to the city as an entity or the traveller as an individual. Building new expressways can devastate

and pollute a city; restricting cars and forcing more people onto public transit can destroy the economic vitality of a city's centre.

We cannot create a new, ideal, totally planned city but have to add to and modify our existing highly complicated structures. There is going to be no technological or economic breakthrough that will miraculously solve all our urban transport problems, only a need to better utilize and improve existing facilities and build new facilities within certain restraints, both the well established economic and technical restraints, and the new social, environmental and aesthetic restraints.

1. URBAN TRANSPORTATION PLANNING

Transportation planning is a relatively new science that has evolved over the last two decades. It started with the numerous origin and destination surveys in the 1940's and early 50's initiated by the U.S. Federal Aid Highway Act of 1944, which for the first time, provided for the use of Federal highway funds in urban areas. These surveys represented the initial large scale efforts to identify and quantify urban travel behaviour. Realizing that a more thorough understanding of travel behaviour required information beyond a measure of traffic volume on a street, trips were categorized into purpose, time of day and mode. Household socio-economic data was also obtained.

The first comprehensive urban transportation study was started in Detroit in 1953 and included most of the factors now regarded as an essential part of the urban transportation planning process. In the intervening years, there have been few changes in the basic format and research work has concentrated on the development and refinement of analytic tools of which there is now a great abundance. Concurrent with the analytic development has been the phenomenal increase in computational capabilities which now permits extensive and rapid handling of the vast quantities of data.

The early U.S. work tended to omit or minimize the role of public transit and this situation was not remedied until the early 60's when analysis of urban transit was made a requirement for the application of Federal highway funds. The Chicago Area

Transportation Study (1962) and the Pittsburgh Area Transportation Study (1963) were among the first to include serious transit recommendations.

The concept of comprehensive urban transportation planning was exported from the U.S.A. to Canada and the "Study of Highway Planning for Metropolitan Vancouver" in 1958 was followed by reports on London (1959), Edmonton (1963), Ottawa-Hull (1965), Victoria (1965) and Toronto (1968).

There is growing concern that for all its analytic and data handling capabilities, the present planning process has major inadequacies both in modeling the transport network and in modeling the urban area in which the network fits. This is understandable when the interacting complexities of an urban area, both tangible and intangible are considered. It becomes all too easy to lose the ground rules and qualifying statements beneath a maze of analytic data. This situation has prompted a number of recent reviews of the urban planning process and its path ahead. It is not appropriate at this point to enter into the fray, but rather to refer to some of this work. A most definitive review of the situation is given in Urban Transportation Planning. Sources of Information on Urban Transportation by Harold Deutschman (1) and briefer reviews by Wilbur Smith (2) and Wolfgang Homburger (3).

In reviewing discussions on new approaches to urban transportation planning (4) (5) (6) (7) (8) (9) (10) (11), the work of the Organization for Economic Cooperation and Development is out-

standing. The OECD Consultative Group on Transportation Research held an exploratory meeting to assess the state of the art in the urban transportation planning process. The introduction to their report (12) can serve as a summing up of the desired changes.

"A new conceptual approach to urban transportation planning is emerging - one which gives increased emphasis to human values and to the social and economic goals of urban development. In this approach economic and engineering efficiency, "demand" for transportation, and profitability no longer serve as the only guiding principles for investment decisions. These conventional criteria are weighed against the social, economic, environmental and aesthetic needs of urban residents: personal mobility, accessibility to urban opportunities, comfort and convenience, clean air, open spaces, pleasing surroundings, the preservation of neighbourhoods and of urban diversity. Underlying this shifting emphasis is the growing conviction that transportation is not an end in itself but a tool for bettering the total condition of urban life; that its objective is not just to move people but to enhance the quality of the cities and to improve the social well-being of their residents; and that planning concerned only with the effects on transportation itself has too often resulted in transportation systems that have failed to contribute effectively to these objectives.

A concomitant premise was that there is a need for a methodology which is more sensitive to the important issues facing urban society and more effective in helping to reach socially responsive decisions. In particular, more sophisticated tools of analysis are required to perceive individual and community preferences and formulate goals and programme objectives in the light of evolving technology and changing habits and values; to search for and generate alternative approaches to meet given objectives; to predict, evaluate and rank the impacts of alternative proposals; and to give adequate recognition to the element of uncertainty in the design of decisions."

Other points made at this preliminary OECD meeting and worth documenting are:

Melvin Webber suggested that transport is so ubiquitous that it is no longer an instrument for economic development. All areas appear to be equally accessible. In cities, automobile ownership is so widespread that we can have urban social centres that need not be concentrated in space. Webber suggested goals for urban planning, one of which was "increasing environmental quality and access to it".

Comments on existing planning models varied from stating they were much better than nothing, they were a little better than nothing, and in few cases worse than nothing. Notwithstanding these comments the next section of this report describes existing transportation planning concepts. Webber's comments

on areas appearing to be equally accessible is not acceptable without qualification. All land in an urban area with a fully developed and uncongested highway network appear to be equally accessible. In this event, any strong relationship between land use and transportation facilities can no longer be used in transportation planning.

The desire to establish human values in transport planning is not entirely new and certain workers have been promoting such a course for several years. The most notable example is probably the discipline of Ekistics created by C.A. Doxiadis, (13) relating man to his environment and settlements. Ekistics is defined as the science of human settlements. Ekistics demonstrates the existance of an overall science of human settlements conditioned by man and influenced by economics, social, political, administrative and technical sciences and the disciplines related to art.

While there is a tendency for some of the work in Ekistics to lose sight of reality, describing and understanding the interaction of man with himself and his city is an important base on which to build concepts for transport planning.

Other workers have related the individual to his transport requirements, and a series of papers make up a special issue of the High Speed Ground Transportation Journal Volume III, No. 1. The sole Canadian contribution to this issue is by Neal Irwin "Public Transport and the Quality of Urban Living".

1.1 The Transportation Planning Process

In order to show how public transit - the principal concern of this report - fits into the transportation planning process, it is necessary to briefly describe the process.

The urban transportation planning process consists of four basic phases; inventory, analysis, forecast, and system evaluation (1). The flow chart (Figure One) shows a typical relationship.

Inventories are made of the existing transportation system. Travel surveys are conducted and investigations are made into the economic structure of the community, population characteristics, and land use. Relationships are established between zonal trip rates and selected socio-economic and land use measures. Future trips for each zone may then be forecasted by employing these relationships with forecasted values of the chosen variable. This is known as "trip-generation" analysis and the forecast socio-economic and land use information is a derivative of projected estimates of population, of employment and of the subsequent allocation of land uses across the urban surface.

Typically, input of future land use serves to adjust transportation demand, the converse of adjusting land use with changes in transport facilities is rarely applied to the full potential inherent in the planning process.

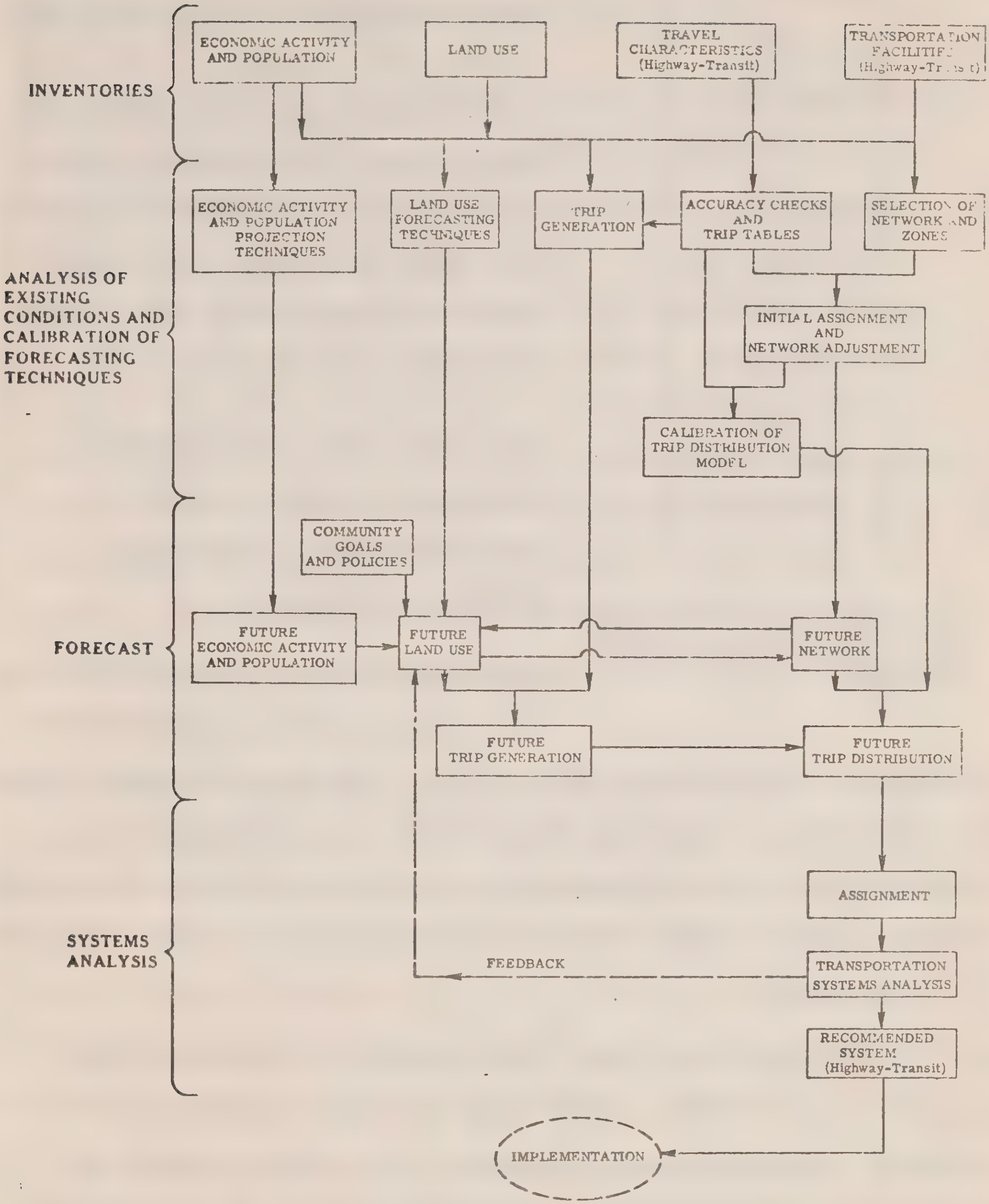
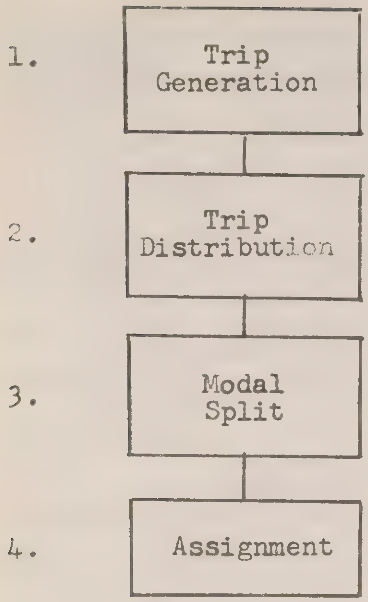


Figure One - Urban Travel Forecasting Process (14)



Four principal sub-models in urban transportation planning.

Having estimated the trips that will orginate and terminate in each zone, a mathematical model is used to distribute these trips between zones and arrive at future travel patterns. This phase is called "trip distribution" and produces a zone to zone trip interchange matrix.

Most models while theoretically based are somewhat empirical in nature and require calibration to existing conditions.

These estimates of future travel are now divided between transit and automobile use by a modal split model. The basic different models are discussed in detail in "Modal Split" U.S. Department of Commerce (15). The bibliography in this document is a comprehensive review of work on modal split analysis and has not been reproduced for this report.

The more sophisticated modal split models are necessary where transit usage is heavy; where usage is light, projections of existing trends are usually adequate. The models attempt to account for characteristics of the traveler and of the transportation system. Certain aspects such as cost and time are readily quantifiable but other factors such as comfort, convenience

and personal attitude to particular modes are not and hence reduce the accuracy and usefulness of such models.

The fourth aspect of the planning process is assignment in which projected automobile and transit trips are assigned to their respective networks. The model is calibrated by assigning existing trips to the existing network. Several alternate networks are usually investigated and the opportunity arises for cost-benefit analysis and transportation implications of alternate land use configurations. These alternate networks are developed by rule of thumb and by experience. Past problems with the cost and time of running the assignment models have often severely restricted the options that can or should be examined. Improvements in computing techniques particularly in increased capacity and speed has made this less of a restriction.

Nevertheless, assignment is one of the weakest links in the planning process because of its heavy reliance on the human factor in designing, costing and analyzing the alternate networks. This is particularly true for the transit system rather than the highway system as options in the latter tend to be obvious and have been subject to considerable more design and analysis. Options in transit systems are frequently wide open.

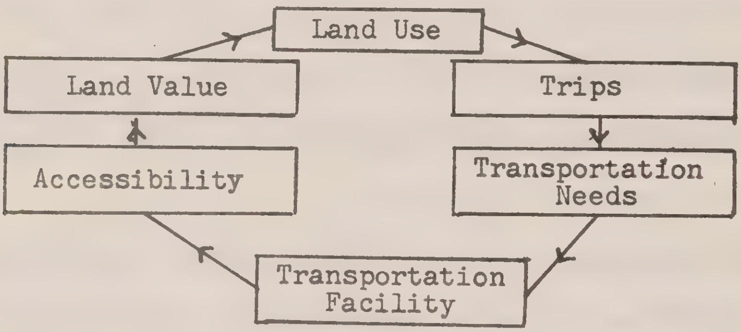
The final aspect of the planning process is implementation and here there is no generalization, but a complex mix of financing,

politics and local attitudes. The planner working with important ground rules of

- planning for the total urban area - not just parts of it
- keeping plans within the financial capability of an area
- keeping all local officials informed of the progress of his planning

must now withdraw to the background and with the usual time delays continue to update his plans in the light of local changes.

In conclusion, if we examine the urban transportation planning process as a continuing dynamic circle --



going round once or twice is not enough. The situation is continuous and so must be the planning.

After this brief review, reference must be made to a more extensive review which comments on future changes in the planning process - "New Directions in Strategic Transportation Planning" (16) prepared for the OECD in October 1969. A summary of the conclusions of this report states:

1. Transportation cannot effectively be separated from the wider aspect of urban development. What is now termed transportation planning can be expected to eventually merge into a more general planning framework.
2. Transportation investment has differential impacts on different community groups. It should be possible to measure these and to expose the essentially political choices that are produced.
3. There is a need for more systematic design procedures.
4. The need for changes in policy frameworks can be anticipated to cope with the above.
5. It is essential to recognize explicitly that there are and will continue to be many uncertainties associated with planning.

Adding to these comments, it should be apparent that it will never be possible to develop a complete accurate model of the urban system or of just the urban transport system, hence it becomes important to interpret planning models with a certain degree of caution. It is all too easy to regard as inviolate plans based on inadequate data, this data having been disguised in a series of statistical manoeuvers.

2. URBAN TRANSPORT DEMAND

In any study of urban transport, it is normal to estimate future transport demand by obtaining or deriving projections of population growth, income growth, growth in car ownership, etc. As such estimates are part of D.J. Reynolds report "Urban Transport in Canada. A Factual and Analytic Review" (17), they are only summarized here.

(i) Most of the urban transport problems in Canada will be in the following nine cities: Quebec, Montreal, Ottawa-Hull, Toronto, Hamilton, Winnipeg, Edmonton, Calgary and Vancouver.

(ii) Car ownership per head will rise from a 1970 level of about 0.33 cars per head to a saturation level of about 0.45 cars per head. This will occur by 1980 in all of Canada except Quebec and the Atlantic Provinces. These latter provinces will reach this level by about 1990.

(iii) Highway traffic will tend to increase correspondingly, that is, from a 100% increase in the decade 1960-1970, traffic will increase by about 60% from 1970 to 1980, 20% from 1980 to 1990 and about 15% from 1990 to 2000.

Other estimates of growth and charts of past growth are included in recent reviews of Canadian Urban Transportation:

Urban Transportation in Canada, CFMM, 1967, (18)

Urban Transportation in Canada, C.B. Lewis, 1965 (19)

The Prospect for Urban Mobility, C.B. Lewis, 1969 (20)

Urban Transportation Developments in Eleven
Canadian Metropolitan Areas, CGRA, (21)

More general data is contained in

Canada 2000 Transportation Projections (22).

2.1 Substitution of Communications for Transportation

Suggestions have been made that some future demand for transportation will be met by increased use of the telephone along with communication advances such as, video phones, data and document transmissions.

The extensive use of the telephone has certainly substituted for some transportation, but, at the same time, has generated demand for transportation. In fact, growth in long distance phone calls is used by several airlines as an indice to estimate future traffic and has shown surprisingly good correlation. Communication technology is already available to permit video phones and the electronic transmission of documents as well as performing more mundane tasks such as controlling domestic appliances. The implementation of this technology is going to be both slow and limited as telephone companies are having difficulties financing even the more essential expansion of their conventional facilities.

Work on this subject (27) suggests that any such substitution will be limited. The effect on urban transit demand in light of its extensive projected growth can be regarded as negligible. However, additional work on this interesting subject is certainly merited.

3. MEETING URBAN TRANSPORTATION DEMAND

3.1 The Present Situation

Urban transport demand is met by obvious and conventional means. By walking and cycling - a small and generally ignored percentage, by automobile - the dominant mode including both drivers and passengers, by public transit - primarily the bus (including streetcars and trolley coaches), secondly by subways and commuter railroads.

The Canadian Urban Transport situation is by no means as well documented as in the U.S.A. However, certain publications cover the subject. Reference is made to "Urban Transportation Developments in Eleven Canadian Cities" (23). Reference is also made to the unpublished annual summaries of the Canadian Transit Association, the Urban Transit Catalogue of DBS (No. 53-216) and related data in the publications of the Canadian Federation of Mayors and Municipalities (18) (24). Care should be taken in using data based on the 1960 census, which is now substantially out of date.

3.2 Urban Transport Modes - Pedestrian

Only a small proportion of trips in origin-destination surveys are made entirely by walking. This leads to a tendency to ignore walking. Yet it is an essential part of man's mobility to be able to move himself at times without mechanical aids, and an essential part of any trip to be able to transfer to, from or between modes by walking.

The time and convenience of such walks can therefore be important in evaluating a trip and its modal alternatives. Many other short trips in city centres or shopping centres depend on walking as the only mode.

The tendency to ignore the pedestrian is particularly inappropriate in the Canadian climate. More by chance than by coherent planning, Montreal has set an example with its array of underground precincts and passageways in the Place de Ville/ Bonaventure complex. These connect stores, office buildings/ hotels and an imposing array of transportation facilities, metro, railroad and airport limousine. The inconvenience of interchange between these many modes is minimized. In modal split analysis, it is common to weight waiting and interchange time by a factor between 1 and 3. (For example, a wait on an unprotected street corner could be weighted by 3, while an interchange between connected subway platforms would be a little over 1.) It is conceivable that an interchange in the Montreal complex, with the possibility of shopping and eating in air conditioned comfort, could accord a factor less than one. Details on attitudes to interchange are discussed in "Human Factors in Transit User Transferring" (25). The report contains gruesome details on the inadequacies of existing interchange and on the lack of attention to interchanges in modern planning. It confirms but fails to quantify the fact that good interchanges affect passenger attitudes to public transit and hence affect patronage.

Discussing improvements to the pedestrian mode is encroaching on urban planning and architecture as much as on transport. Technological innovation in pedestrian movement is covered in the next section. However, the biggest improvements are not technological, they require an awareness of the importance of the pedestrian mode. Most pedestrian trips are captive journeys, the individual has already left his automobile or bus and is completing a trip (or vice versa).

Alternately, the trip is so short or so structured as to preclude the use of a car or of transit. There has been no incentive to spend effort or money in improving these captive trips. However, as our affluent Canadian becomes less inclined to tolerate the inconvenience of such trips, he will attempt to minimize them. He will accelerate the move to suburban shopping malls where trips between stores/cinema/restaurant can take place in air conditioned comfort and a single trip through the slush/cold/humidity replaces the many.

At this point, it becomes necessary to raise a vital and controversial question. Is it desirable to preserve the CBD in its historical form and importance? This question is equally relevant to the transport planner, the urban planner and the architect.

3.3 The Form of the City

In discussing urban transportation planning, the relation between land use and transport was questioned. Land use planning can serve as an input to transport planning and conversely transport facilities can affect land use. This is the case with the growing

ownership and usage of automobiles which has tended to decentralize the larger cities in North America. The impact has been greater in the U.S.A. than in Canada. The larger cities of the U.S. have suffered extensive traffic congestion and the ensuing decentralization has had debilitating effects on many central cities compounded by the political subdivisions that fragment most metropolitan areas. Canadian cities are generally either more plenary or have some vestige of regional government, regional planning or regional public transport.

The city was built as a communication centre, and when communications meant proximity the compact city developed. The automobile as a new means of communication has extended man's radius of activity and is now in conflict with the compactness of old cities, so that it becomes necessary to reconcile the old idea of a city with the new idea of mobility (26).

Decentralization in Canada has, therefore, not reached a point of irreversability and several options can be considered.

1 - A strong central city where autocratic regional planning restrains the trends to decentralize. Acceptable alternatives for the automobile must be provided for trips to the CBD, particularly when the demand for highway use exceeds the supply and cannot be satisfied with available financial resources or without destroying the character of the center city. Bremen Germany is a good example of this attitude. The entire city centre is restricted to public transport with cars approaching only to a circumferential road provided with extensive parking spaces. Many other European cities have reason to

preserve the character and history of their city centres. In Canada, only Quebec City can claim obvious character, other cities have downtown areas that are generally undistinguished. Here the main advantage is that a strong city centre improves the viability of public transport and so retains the mobility of the large minority of people for when car ownership is not possible. (The mobility of people without access to cars is discussed further in Section 5).

2 - The opposite of a city with a dominant centre is the totally diverse city. Here, facilities are spread over the highway network providing unprecidented mobility for those with automobiles. Public transport becomes minimal, severely restricting mobility of the disadvantaged. Overall transport efficiency decreases and air pollution increases. Los Angeles is the principal example of the diverse city. It does not work perfectly as the diversity is insufficiently even to prevent certain highway links overloading and hence becoming congested. No Canadian city in fact or in planning is approaching concept of total diversity. Toronto is the only city with the topography and potential population to support such a city form.

3 - The third and compromise city is the form in which the larger Canadian cities are now evolving - that of partial decentralization. The centre city remains a focal point for specialized retailing, administrative and judicial functions, specialized social functions such as opera and theatre, and other activities that find it advantageous to remain central. Many retail outlets and certain professional services and

entertainments operate in suburban centres and in the larger centres considerable suburban employment enclaves can develop.

Partial decentralization can be a very rational form of development, it can reduce CBD congestion and help public transit by providing "reverse" riding. However, this is contingent with a certain degree of logical plannning. Suburban development should be such that it can provide a viable nodal point for transit services - Ottawa is a good example. The often typical situation in the U.S. is for suburban development to lie outside the city limits in a suburban municipality with lower land costs, lower taxes and favourable bylaws. This "competition" with the city has disadvantages similar to these cited against fragmented jurisdictions in metropolitan areas. Tax base is removed from the central city which is left holding the ghetto costs of welfare, policing and redevelopment. Suburban developments cannot be served by transit due to; franchise boundary restrictions or large distances from the city, or they cannot be served efficiently by transit due to low density or higher income housing which generates little bus traffic. The result becomes an automobile oriented community with restricted mobility for those without access to a car. The area then tends to function remotely from the city, and in fact would have been better to be planned as a separate entity instead of part of the urban sprawl. Section 6.2 discusses the development of new communities.

Fortunately, Canada has few fragmented metropolitan areas and can indulge in planned decentralization with fewer problems than our neighbours, but it is not always evident that the lesson is being learned. Cases have been cited of residents in suburban Toronto who have not travelled downtown from one year end to the next, and whose principal advantage of living in a metropolis is the availability of; an international airport; lower retail prices; choice of television channels and newspapers and a feeling of belonging - probably imported from the cathode ray screen.

This subject calls for much greater consideration than is possible here. It is impossible to answer the question of whether the people should have what they appear to want individually - a decentralized city with automobile dependence, or what is good for them collectively - a more planned, more efficient urban environment with provision for the less priviledged minorities. In examining future trends in public transport, the existing growth in decentralization and the options still open to Canadian cities must be considered. However, the strong probability would appear to be that of minimum change and hence a continuation of the trend to automobile domination.

The option to retain a strong centre city returns us to the problem of the pedestrian. More planning and greater consideration must be given to the pedestrian. This means segregation from traffic, protection from the weather and more convenient

modal interchange. This latter item ranging from simple bus shelters to multi-mode transportation centre. The economics of such facilities may often be difficult to justify. However, they should not be examined in isolation, but as part of an overall plan for the urban area.

3.4 Urban Transport Modes - Automobile

Canadá's seven million cars - one for every three people, cover some 65 billion miles each year, of which slightly less than half is in urban areas. (50% by one estimate (17), 43% by another). In comparison, Canada has 8,000 buses and streetcars and 700 subway cars which provide approximately 4.5 billion passenger miles (DBS). Allowing an average urban car occupancy of 1.3, the car then accounts for 89% of all urban passenger miles, slightly less in terms of journeys as car trips tend to be longer than bus trips.

Thus, the car is already the overwhelmingly dominant mode on the average, but not in certain circumstances. Journeys to and from work during weekday rush hours create a demand for road space that has been impossible to fill in medium and large cities. The ensuing congestion and delay diverts many trips onto public transport in proportion to the dominance of CBD employment, the size of the city and the inadequacy of the highway facilities. Table One shows the strong divergence from the 89% average, ranging from a high of 62.9% in Winnipeg to a low of 42.8% in Toronto. The American cities show similar trends but with

greater divergence.

Table One - CBD Trips on Typical Weekday (23) (p. 321)

City	Population (m.) 1960 or 1965	Year of Cordon Count	% by Car	% by Transit
Toronto	2.1	1960	42.8	57.2
Vancouver	0.9	1953	52.8	47.2
Winnipeg	0.5	1957	62.9	37.1
Cleveland	1.8	1963	57.0	43.0
Los Angeles	6.7	1960	74.6	25.4
Nashville	0.4	1960	85.9	14.1
New York	10.7	1960	28.5	71.5
San Francisco	2.8	1959	47.1	52.9

Note that walking trips are not included.

The restrain in car use for work trips to the CBD diverts people to transit - the so called "choice" riders. But as discussed in the introduction congestion has to almost reach the chaos stage before this "choice" is exercised. This level of congestion affects not only the commuter who will tolerate it but also the commercial vehicles and buses for whom the cost of congestion can be readily calculated. Solutions to the problem are covered by Reynolds (17) in his discussion of pricing roads and parking. The partial solution and current trend is to build as many highways as possible contingent on financial, aesthetic and planning restraints. Some comment is relevant on the vocal opposition to urban disturbance that is presently delaying certain urban expressway projects. This should not be construed as a fundamental opposition to new roads - a view held by only a small minority. The public per se has an insatiable appetite for new roads on which to mobilize

their automobiles, as long as these roads go through someone elses backyards and not their own.

New roads are a correct solution and Reynolds indicates the expenditures that will be necessary in the next 30 years. When enough highway capacity or parking spaces cannot be provided, a situation of mobility restraint exists and other alternatives are necessary. This means public transport - dealt with in the next section. It also suggests that an attempt should be made to control traffic volumes to a level that will provide near optimum efficiency for other road users. Any artificial adjustment to the modal split will be unpopular with the electorate - the majority of whom own if not worship cars. The options are:

- To devise and build a public transport system that is competitive with the car in availability comfort, cost speed and convenience. New transport technology is discussed in Section 4, but analysis of many schemes has indicated that it is impossible to compete with the car in both cost and convenience. Hence, urban highways are likely to remain congested.

- To price a proportion of car trips off the road. Paying for what you use is a very fair concept and road pricing is attractive. Several ingenious systems have been devised and tested, and while these could undoubtedly be made technically feasible, all require fitments to

individual cars as well as permanent roadside installations with the ensuing capital, maintainence and administrative expenses appearing prohibitive. However, if through traffic can be diverted from the CBD and most large cities have expressways built or planned to do this, almost all CBD traffic should have reason to stop in the CBD. Hence, effective pricing control can be achieved merely by controlling the cost of parking. Not only municipal and on-street parking but a uniform control of all public and private parking.

Pittsburgh, Pennsylvania was one of the first cities to institute such a system by placing a tax on all parking. The present 10% tax is passed directly onto the motorists by private parking concerns and the public parking authority. As well as all day parking, the latter body provides both short and medium term parking for shopping purposes, such parking being often subsidized by CBD merchants. Effectively, long term parking is also subsidizing short term parking, and an adequate supply of the latter can always be assured by reallocation of long term spaces. A single planning authority for all parking can also restrict the provision of additional spaces and hence partially control the congestion on CBD streets. Good planning will also ensure that access to and egress from parking facilities causes the minimum disruption to traffic flow in particular prohibiting exits

onto streets that are already over capacity. One snag in the overall control of parking is free employee parking. This is not substantial in Pittsburgh, whereas in Ottawa for example, the extensive "free" parking - particularly for Federal government employees - could thwart the success of parking control, unless some municipal control could be obtained and exercised.

- The use of small cars: Greater efficiency in road use would result from the exclusive use of small cars on urban streets. However, in a typical street mix, with trucks, buses and other cars almost negligible improvement would result (17). It is difficult to conceive of any acceptable regulation restricting all but small cars. The bulk of one car families use their car for intercity and vacation trips requiring the space and convenience of a large car. There is more incentive for two car families to have a small car as a second car, both from the economics of purchase and operation and the ease of driving and parking. An incentive can be provided in addition to the incremental tax on engine size and fuel taxes - which favour small engines, by converting some parking spaces into smaller units, designated "for small or compact cars" and charging a reduced parking rate, possibly in inverse proportion to the increase in spaces obtained. Considerable psychological

pressure is brought to bear on large car owners who find that they cannot use a proportion of the available parking spaces while the small car owner is not so limited. Obviously, the proportion of spaces to be reduced must be relative to the present ownership of small cars, but it could include some on-street parking, particularly where space limitations or lane width favour smaller spaces.

The advantages and possibilities of small urban cars powered electrically or by a hybrid source is discussed in Section 4, 5 & 5.1.

As well as the options discussed above, more attention has to be given to implementing existing techniques that can improve the efficiency of urban streets. These techniques range from a computer controlled network of traffic signals, grade separated intersections, better signing and lighting down to a greater use of reflecting paint to induce better lane and turn discipline. This leads to a brief mention of an important subject that is beyond the scope of this report - driver training, licensing and highway safety.

One of the prices our society pays for its extensive mobility is the death and injury of a proportion of the population every year along with considerable property damage. While the

present accident level is tolerated by an indifferent public and while some accidents are an inevitable price for mobility it should be firm federal and provincial government policy to minimize accidents. Canada has little to be proud of in this respect and the list below mentions but a few areas where action is desired:

- vehicles should be built to be as safe as possible,
- regular inspection to eliminate unsafe vehicles from the road
- adequate driving instruction for young people,
- more stringent medical check-ups for drivers, particularly older drivers,
- campaigns to improve driver education,
- campaigns to adopt the use of safety devices built into vehicles,
- construction and modification of highways and streets to minimize hazards.

A more detailed list of improvement is contained in "An Evaluation of Urban Transport Efficiency in Canada" (28).

All the safety measures above cost money, some coming directly from the vehicle owner, some from the taxpayer. Certain safety measures impose restraints and inconvenience on the user which are/will be unpopular. As car owners constitute the majority of voters, there is an understandable but unfortunate reluctance to legislate as drastically as is desirable. No reivew has been made here of the extensive literature on highway safety - much of it originating in the United States. However, it is often possible to equate the cost of accidents against the cost of the suggested improvements. No one wants to put a price on his life but by our continued complacency to highway safety, we are in fact pricing life at an all too low figure and the lives we are under pricing are our own.

3.5 Urban Transport Modes: Public Transport

In Canada 11% of urban journeys are made on public transport. 15% of these transit trips are on the subway systems of Toronto and Montreal, the remaining 85% are carried on surface transit, bus, streetcar and trolley coach.

Table 2 - Percentage of Urban Trips** by Mode

Mode	% of Transit	% of Urban Trips
Auto	--	89. %
Bus	65%	7.1%
Trolley Coach	11%	1.2%
Streetcar	8%	0.9%
Subway*	15%	1.6%

* Note that the figures reflect fares paid and hence transfer passengers are only counted once by their initial mode.

** Based on the approximation that the average urban transit and urban auto trip are of equal length.

Commuter railroad figures are not included in Table 2, but are not significant in Canada. The only heavy services are the CP Rigaud Line and CN Mount Royal Line, both in Montreal and the CN operated GO transit in Toronto. Similarly taxi services, which may or may not be classified as public transport, are not included. Not for their lack of significance but rather the lack of available data.

<u>Service</u>

Past trends in public transport are shown in Figure 2, 3 and 4. The impact of the depression and of the automobile after World War II are very clear. Note that the Canadian decline is less severe than the U.S., this is important because it implies a viability in Canadian transit that it would be desirable to define and reinforce. One obvious reason is the difference in affluence and hence car ownership. Canada has 3 persons per car while the U.S.A. has 2.2 persons per car. Reference to Table 3 shows the large incremental change in transit use with the ownership of 1 or 2 cars, particularly for non-CBD trips. It follows that as car ownership increases in the next thirty years approaching the same saturation level as in the U.S., people will reduce their transit usage descending as it were the steps in Table 3. However, two conflicting facts must also be considered; many U.S. cities are larger than any in Canada and the size of the city affects transit usage. This is shown in Figure Two where larger cities have higher per capita transit usage. Conversely, urban expressways are more common in the U.S.A. and these serve to reduce transit usage.

Figure 2

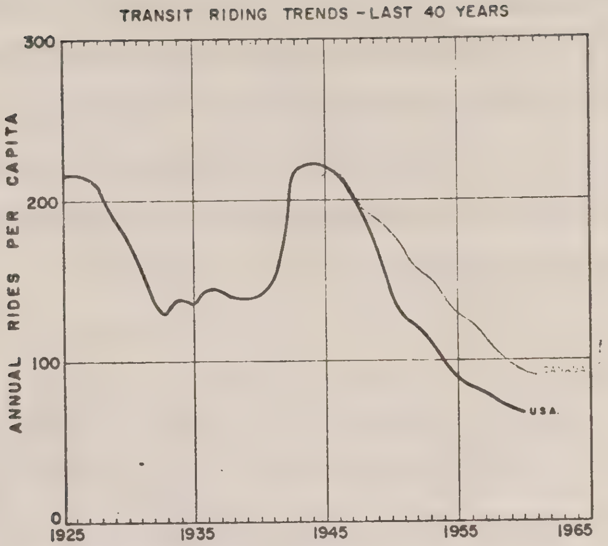
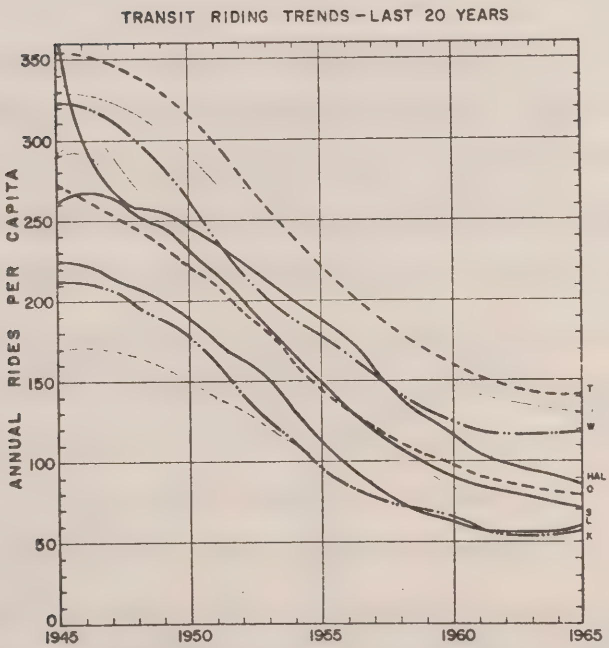


Figure 3

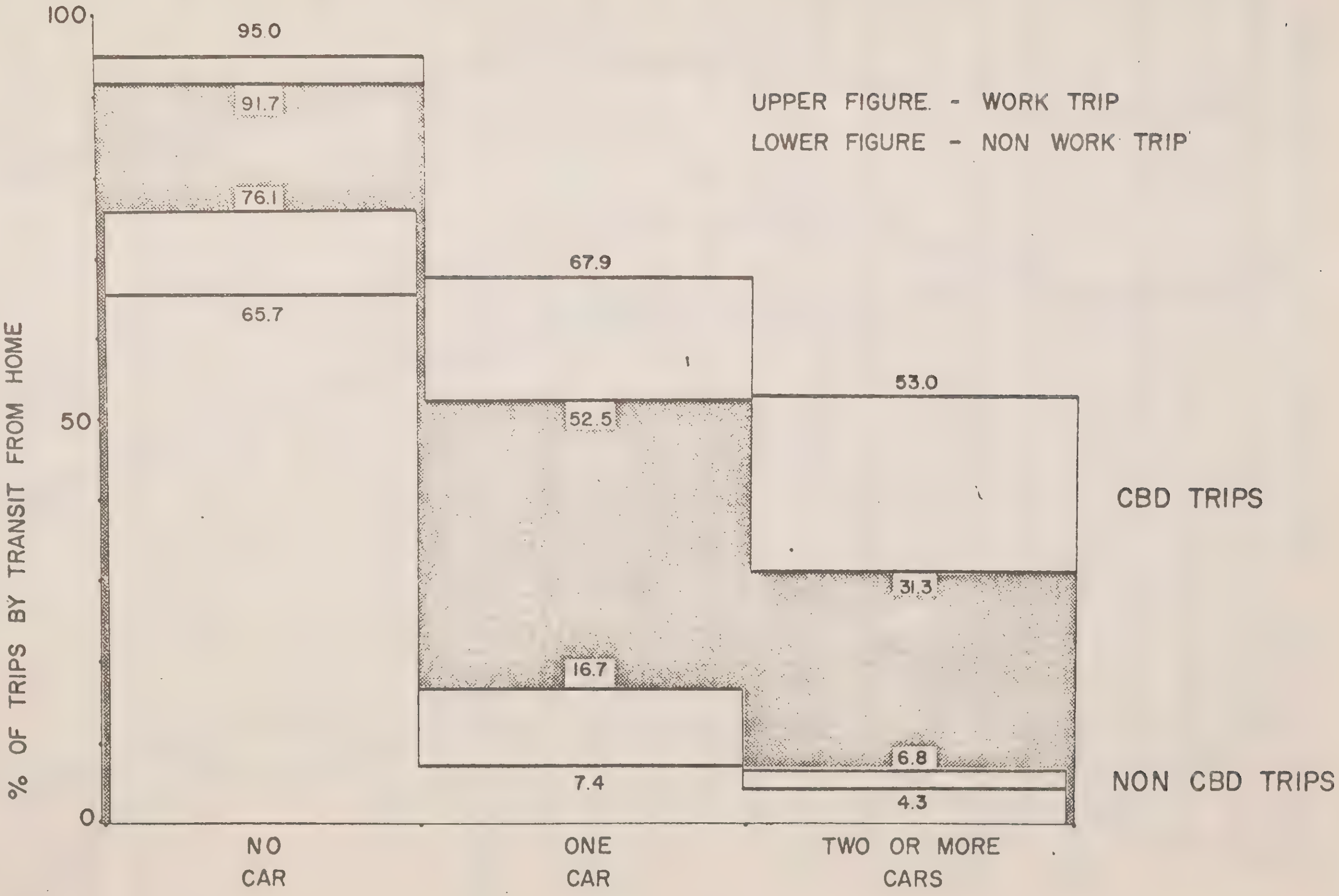


T = Toronto
M = Montreal
W = Winnipeg
HAL = Halifax
O = Ottawa
S = Saskatoon
L = Lakehead
K = Kitchener

TABLE 3

RELATIVE USE OF TRANSIT BY CAR OWNERSHIP

(PENN JERSEY TRANSPORTATION STUDY VOL. I 1964)



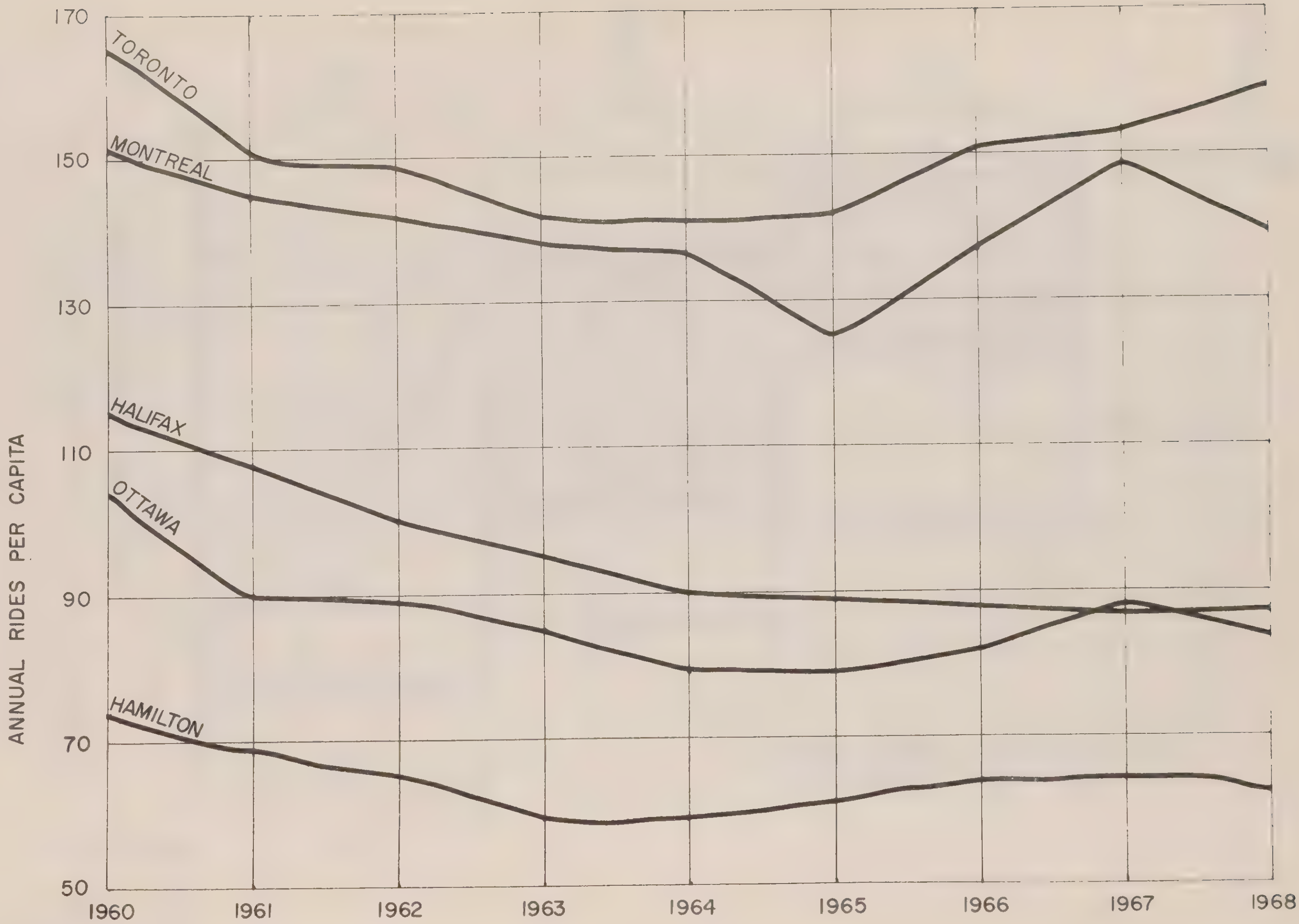


Figure 4 Transit Riding Trends in Canada 1960 to 1968

Without quantitative data, it is impossible to state how these three effects; car ownership, city size, expressways, actually effect the amount of transit riding. There are other reasons, even less quantifiable and probably as or more important, to account for the higher transit riding in Canada. These reasons evolve around the efficient, superior transit service that Canada has enjoyed for several decades. A majority of transit undertaking in Canada have been publicly owned for many years either as a municipal department, a transportation commission or as part of a utility. The only major exceptions are Quebec City and Windsor, both still served by private bus companies. Public operation has tended to be more responsive to public demand and Canadian operators have a justifiable reputation for high standards of maintenance and cleanliness. Couple this with the operating efficiency (and hence lower fares) and with the freedom from urban crime and racial problems in Canada to explain the high acceptance of transit riding and the avoidance of the negative social image that has and is plaguing U.S. transit operators.

The frequently mentioned vicious spiral of:
decreased patronage = higher fares + lower service = decreased patronage has not reached the same stage in Canada as in the U.S.A. Although in the past decade almost all Canadian undertakings have reported deficit operation. Deficits are handled in so many ways that it is difficult to table a comparative list. Table 4 derived from DBS 1967 statistics can only be regarded as an approximate breakdown.

Table 4 - 1967 Net Transit Operating Income by Province

	No. of Systems	Net Income in Million $	Income as % of Operating Revenue	Average Fare ¢
Atlantic Provinces	10	- 0.500	- 5.2%	11
Quebec	24	- 0.185	- 0.2%	23
Ontario	28	+ 4.869	+ 6.0%	18
Manitoba	2	- 2.431	- 21.5%	13
Saskatchewan	4	- 0.690	- 19.0%	15
Alberta	6	- 1.696	- 14.2%	15
British Columbia	10	- 1.623	- 9.0%	20
Canada	84	- 2.257	- 1.0%	19

Note In 1967, the 84 operators paid $6.114 million in provincial fuel taxes, $4.915 million in operating taxes and licences and approximately $0.542 in federal taxes. Certain Western properties now obtain a rebate on fuel taxes.

Table 4 illustrates the difference between the Western properties where municipal control readily permits deficit funding from taxes, and the Eastern properties where independent Commissions are under pressure to pay for all service from the fare box. However, in the latter case, concealed subsidies in the form of capital assistance or tax rebates are possible. In general, deficit financing is accepted in Canada but is by no means a continuing solution to support transit. Cities have a limited tax base and growing needs for money to cope with the many urban problems besides transit. There are obvious limits to the extent of transit subsidies and there is every indication that recent fare increases in Eastern Canada will be followed by increases in the West. Whether this will push public transport in Canada onto the slippery downward spiral is difficult to determine. Montreal

raised its fares twice, increasing the ticket price 60% from 18¢ to 30¢ and passenger volume dropped 8.9% partly offset by the improved service provided by the new subway. At one time the Simpson and Curtiss formula:

$$\% \text{ drop in riders} = 0.3 \, (\% \text{ fare increase}) - 0.8$$

was widely applicable in the U.S.A. but with the high proportion of captive riders no longer applies, and the price elasticity of transit in some U.S. cities is regarded as being negligible. There is inadequate data to comment on Canadian elasticity, although Table 5 demonstrating the lower fares in Canada relative to city size and the higher standard of transit service would indicate that there should be some elasticity.

An interesting exercise is illustrated in Figure 5 for the New York City Transit Authority where a patronage increase from 1957 to 1965 under a constant 15¢ fare and growing deficit was reversed into a decline when the 20¢ fare was introduced. The introduction in 1970 of a 30¢ fare is expected to show a lower percentage decline because of the few real alternatives available to New York transit riders.

Although the data in this section is of considerable interest, it is impossible to adequately quantify the relationship between the U.S. and Canadian transit situation or to quantify transit riding to city size or to the fare. However, there is an indication that transit in Canada, having successfully coped with the 1960's, is entering the 1970's in an increasing unfavourable position.

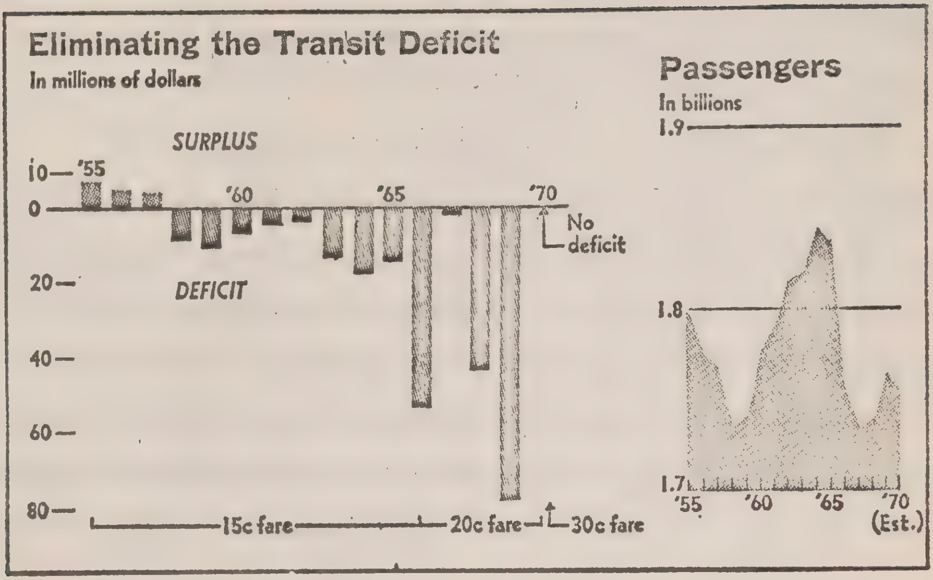


Figure Five - NYCTA (New York) Transit Data

TABLE FIVE

COMPARISON OF URBAN TRANSIT SERVICE

Canadian Cities	Population Metropolitan Area	No. of Transit Vehicles per 1000 population	Basic * Fare
Montreal	2,320	1.0	30¢
Toronto	2,012	1.0	25¢
Vancouver	850	0.7	*** 25¢
Ottawa	482	0.6	25¢
Edmonton	385	0.8	** 20¢
Halifax	188	0.6	12¢
Thunder Bay	98	0.5	17¢
U.S. Cities			
Philadelphia	4,343	0.6	35¢
Pittsburgh	2,405	0.4	40¢
Washington	2,063	0.6	40¢
New Orleans	907	0.5	15¢
Columbus	755	0.3	40¢
Youngstown/Warren	509	0.1	na.
Johnstown	281	0.2	25¢

* Fare for Central Zone with transfer based on cheapest ticket or token cost 1970.
Note that express services often require a premium fare.

** Has $10 unlimited monthly pass

*** Has $5 senior citizen pass, 25¢ downtown fare, 50¢ Sunday pass.

3.5.1 Trends in Canadian Urban Public Transport

Public transport is like a wholesale operation. Although travellers need not start at the same origin and end at the same destination, they must assemble themselves in time and in space and in sufficient quantities to justify specialized equipment and bulk treatment (29).

Canadians do not like assembling themselves in time and space or submitting to bulk treatment and hence the widespread use of the automobile even in many illogical situations. The use of the car will continue and public transport will increasingly find itself with two distinct markets:

1a. The Captive Market. People without the use of a car, those who are too young, too old, too poor or too ill to own or drive a car. This is a market for base transit service at all times of the day. The proportions of the population in these categories are discussed in Section 5.2.

2a. The Semi-choice Market. People with the use of a car but who do not use it for the journey to work because of congestion, parking problems, or requirements of other family members for the car. Normally these people would be regarded as choice riders but in fact when they ride transit they have a limited choice.

2b. The Choice Market. People with the use of a car but who use transit because it is cheaper or faster or because they

dislike driving. Use is almost exclusively for CBD work journeys. Also people (mainly in large cities) who could afford a car but choose not to because of the inconvenience of ownership - licensing, maintenance, garaging. These people tend to use taxis and rental cars but will use transit for work journeys and on other occasions when it is convenient.

It should be immediately apparent that these classes present public transport with a limited base market and a very heavy rush hour market. The trend over the last decade has seen the base traffic decline and peak hour traffic expand. Figure 6 shows a typical hourly flow comparison for transit and automobile in a composite of North American cities. Peaks in the U.S.A. are becoming more pronounced for transit and the Canadian situation will follow this trend.

<u>Table 6 - Percentage of Daily Transit Passengers in a Single Peak Hour</u> (Different Years 1963-67)

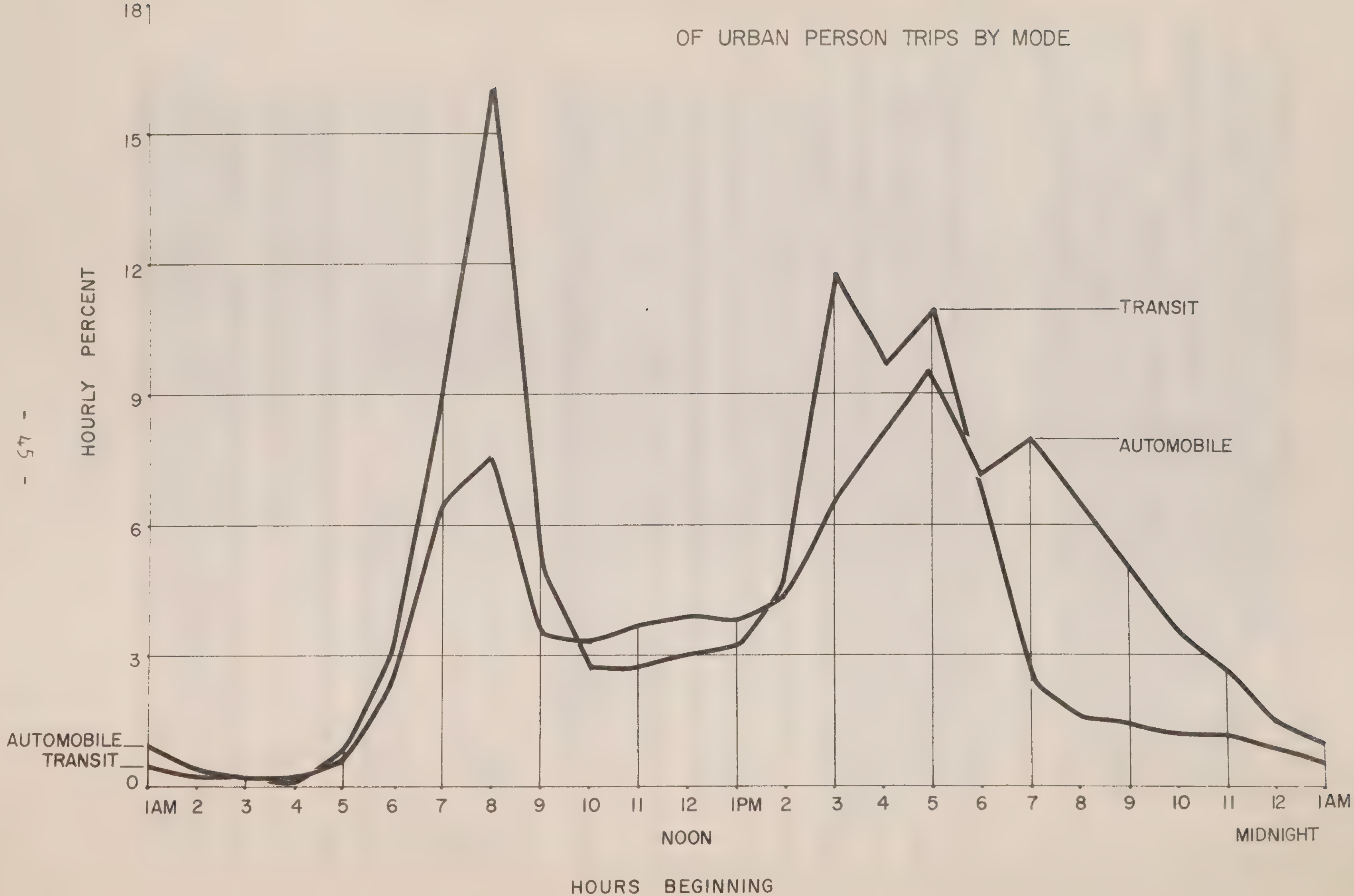
Toronto	12.0%
New York	15.0%
Philadelphia	16.5%
Boston	17.2%
Chicago	19.2%
Cleveland	22.5%
Pittsburgh (rail-rapid lines)	28.0%
Chicago Commuter Railroads	29.1%

Heavy demand peaks make inefficient use of transit equipment and staff, so that this trend will accelerate the spiral of increased costs/reduced service mentioned above. Attempts to introduce time variable pricing have been moderately successful as in the case of reduced fares for senior citizens available

Figure Six

COMPOSITE HOURLY VARIATION

OF URBAN PERSON TRIPS BY MODE



off peak (Ottawa is an odd exception). Attempts to stagger peak hours have been less successful, although there are causes where factory/office/school/store hours can be advantageously adjusted. More study in spreading the peak would be merited.

Outside peak hours transit has an increasing difficulty in covering its operating costs without decreasing service to a detrimental level. Many systems or individual routes in the U.S.A. have diminished to become rush hour only.

Table 7 - Chicago Transit Use

Relative efficiency (%) is the ratio of seat miles used to seat miles supplied.

Commuter Railroad	- 83%
Rapid Transit	- 48%
Surface Transit	- 40%

In Chicago the private railroads are virtually a rush hour operation and can adjust their supply to closely match the demand. The public transit systems must maintain an off peak service and has a much lower relative efficiency. Rapid Transit is more efficient than buses because of its great ability to absorb rush hour loads.

Still considering conditions in the U.S.A., the plight of transit or smaller cities has become pronounced. Here lower street congestion levels has reduced the transit market to one based almost entirely on captive passengers. 250 bus operators have gone out of business in the last 15 years. In 1969 , Akron Ohio (a city of almost half a million people) had the

distinction of becoming the largest city in the developed world without any public transport. The city has since purchased 50 buses with federal assistance and provides a minimal service, principally used by the under-priviledged.

Table 8 - Estimated Change in Population and Transit Usage for Different Sized U.S. Cities 1960-1980 (23)

Urban Population Million	Per Cent Change In Population	Daily Transit Trips
1.0 - 5.0	133.0	86.7
0.5 - 1.0	15.5	- 27.5
1.1 - 0.5	43.9	- 39.6
Under 0.1	- 16.2	-100.0

To summarize, the level of transit riding in Canada may be expected to hold at a fairly steady level over the remainder of the century. An unfavourable increase in peak riding coupled with increased labour costs (labour costs represent 65 to 80% of transit costs) cannot be offset by greater efficiency as there is very limited room for improvement, and as a result fares will rise continually, offset to an extent by municipal and possibly provincial subsidies. Preferential subsidies might be expected for the under-priviledged as a part of the social welfare operation. Greater use of zone fares can be expected to attempt to avoid discouraging short distance riders.

The constant level of ridership will not be evenly distributed across urban areas. Ridership in large cities will expand, in medium cities it will fall slightly, while small cities will eventually lose all transit service other than school buses. Refer to Table 8 for U.S. estimates.

Public Transport Capacities

In this section, the concept of public transport was discussed as a wholesale operation with passengers having to assemble themselves in time and in space and in sufficient quantities to justify specialized equipment and bulk treatment. Obviously such bulk treatment is a more efficient way of moving people, a bus with 70 people takes the same road space as 3 small cars with 4.5 people (Average car occupancy at 1.5). Trains and rapid transit make an even more efficient use of lanes. Fuel and maintenance costs per passenger mile are less for a bus and less still for a train.

Normal practice in a transport review produces a table showing the comparative capacities of various transport modes, but in fact the variation in utilization within a mode is so large as to render such a table invalid. Cars on a single lane of roadway can vary from urban flow at 8 m.p.h. and 30 foot spacing, a theoretical 1400 cars per hour to an urban motorway at 60 m.p.h. and 125 foot spacing - 2,400 cars per hour, with a maximum flow rate between these speeds. Car spacing according to the highway code will give much lower values of capacity, commonly quoted figures are 500 cph for urban streets to 1,500 for motorways. These figures should be multiplied by 1.5 as an indication of average car occupancy. Actual road counts have shown occupancy for the jouney to work to vary from 1.1 to 1.7 for different cities.

Buses have a crush capacity of 60 to 100 passengers and can operate as closely as 20 seconds apart with stops on city streets, closer with their own lane and segregated stops. This gives a capacity of up to 18,000 ppphd* but on city streets 8,000 to 10,000 ppphd is regarded as a practical limit. Table 9 shows the capacity of bus and rapid transit services in the U.S.A. (52). As buses need a crew of one, such high volumes are very inefficient in manpower and where travel corridors are capable of providing such "medium density" volumes or higher volumes, rapid transit is a viable proposition. Planners usually regard 10,000 to 20,000 ppphd as the minimum volumes to justify new rapid transit facilities, but many existing routes are able to cover their costs at much lower volumes, admittedly without necessarily contributing to any capital debt retirement, their construction costs having been amortized long ago. Cleveland Transit System is the outstanding example of an economic rail transit system handling low volumes, but the CTS system as a whole has been making an increasing deficit, resulting in a severe increase in fares in late 1970.

The increasing use of automatic train control permits trains to run 90 seconds apart and theoretically this may be reduced to 70 seconds, below which time the duration of station stops becomes dominant. Train length is not theoretically limited other than by station platform length. Trains rarely exceed 12 cars and 10 cars is regarded as normal. Car dimensions vary from 42 feet (Berlin) to 75 feet (Toronto) in length and from 7'6" to 10'6" in

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* ppphd - passengers per peak hour direction.

TYPE OF MASS TRANSIT OPERATION	LOCATION	VEHICLES OR TRAINS PER HOUR	TOTAL PSGRS.		PSGRS/VEH OR TRAIN Full hour	REMARKS
			Full Hour	15-20 min rate/hour		
Buses on City Streets	Hillside Ave., Queens, New York City	150	10,251	10,824	68	Several routes, separate sets of bus stops
Buses on Reserved Lanes	Main St., Rochester, N. Y.	93	4,982	-	54	Curb lane
	Washington Blvd., Chicago	66	3,235	3,600	49	Center lane and loading area in one-way street.
Buses on Exclusive Lanes	Ramp to PNYA Bus Terminal, New York City	511	23,187	28,556	45	Considerable gradient
	Bay Bridge, San Francisco	222*	9,187*	12,205*	41	Temporary lane (1962); not at capacity
Buses on Expressways, Bridges, etc.	Lincoln Tunnel, New York	480	21,600	22,860	45	Preferential right of way
	Bay Bridge, San Francisco	269*	10,693*	13,880*	40	No preferential right of way
	Lake Shore Drive, Chicago	99	5,595	6,350	57	No preferential right of way
Rail Rapid Transit	IND Queens Line, New York	32	61,400	71,790	1,920	11-car trains, 60-ft cars
	IND 8th Ave. Express, N. Y.	30	62,030	69,570	2,070	10-car trains, 60-ft cars
	IRT Lex. Ave., New York	31	44,510	50,700	1,440	10-car trains, 51-ft cars
	Yonge St., Toronto	28	35,166	39,850	1,260	8-car trains, 60-ft cars

* Some intercity buses also used this facility, but are not included in totals.

Table 9 - Listing of the higher transit volumes in the US and Canada

width (53). Design capacity of a car is taken as the number of seats plus 6 passengers per square metre over the remaining floor area. This corresponds to just less than 2 square feet per standing passenger, a crush load can reduce this to 1.5 square feet and hence some of the larger transit cars can crowd 300 people in. A theoretical volume of 120,000 ppphd is then reached by 10 car trains on 90 second headways. These volumes are physically uncomfortable for passengers and the normal capacity of a two track transit line is often quoted at 60,000 ppphd.

A concept of a continuous train with continuous platforms proposed by Professor F. T. Barwell (54) could provide a capacity of up to 360,000 ppphd, allowing 2.5 square feet per passenger, considerably more comfortable than a crush loading of 1.5 square feet per passenger. Yet more comfortable accommodation would provide a capacity of 200,000 ppphd with a lower standing/seating ratio.

Changes in technology will have very limited effect on urban public transport and are discussed in the next section.

4. TECHNOLOGY IN URBAN TRANSPORT

4.1 Introduction

There is an almost no limit to the technology that can be applied to urban transport given the desire and the money. There is an abundance of published material describing, analysing and attempting to cost an array of transport technology that is in use, has been developed or is merely conceived. The most important problem on urban transport is not developing or selecting new technology but implementing it.

The most concise references to transport technology are contained in:

- Urban Rapid Transit Concepts and Evaluation (30)

  Chapter 5 discusses technological Fundamentals - Guidance/ Adhesion/Performance/Automatic Control and Noise factors.
- Manchester Rapid Transit Study (31)

  A recent hardheaded review of alternate transit systems technology with certain comparative costs.
- Tomorrow's Transportation (32)

  A review of general technology applicable to transport in the U.S. city, obtained from the studies listed below.

Further reference can be made to the extensive work performed for the U.S. government in the HUD program "Study in New Systems of Urban Transportation", listed below.

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4.2 Pedestrian Mode

The principal advances needed to improve the walking portions of journeys are in the hands of the city planners and architects. Just as vertical transport elevators and escalators are designed to handle the volumes in particular buildings, horizontal transport in high activity areas can be similarly considered. Several types of "moving sidewalks" or ramps are available and in use at airports, shopping centres and other large complexes. These devices are limited in speed by their take off differential. Generally in North America, they operate at about 90 feet per minute, in Europe at about 120 feet per minute and in the USSR where the populace is disinclined to sue the authorities because of an accident at about 180 feet per minute. 90 feet per minute or about 1 mile/h is slower than a normal walking pace, which reduces the utility of such devices to relatively short distances - say up to 1000 feet.

Bouladon of the Geneva Batelle Institute has proposed a moving belt with an "integrator" to accelerate and decelerate people, thereby achieving speeds as high as 9 mile/h. Development of this concept is underway in Britain. However, the complexity and hence expense of the terminal equipment will limit its application to high density links, or areas with high benefits relative to cost - for example in airports. It is for airport application that most attention has been paid to moving people short distances. Long walks between parking areas, check-in counters and gates are particularly annoying to the air traveller, and airport designers have installed moving walkways, small automated vehicles such as the Westinghouse Skybus (at Tampa

and Seattle) and are investigating the moving lounge concept. (For example the Budd Planemate or the Dulles Airport installation)

In attempting to develop a new transit system that is competitive in all respects with the private car, numerous concepts have evolved and are generally grouped as Small Car Concepts (SCC). These are discussed under the later section "rapid transit" as they rely for all or part of their travel on fixed guideways. Their use as an urban transport network is unlikely due to the high costs relative to their carrying capacity and the service provided. However these concepts become more attractive in high density, high congestion areas with their use as links in activity centres or as small distributor networks in the city centre. It is in the city centre that all public transport is least efficient, surface transport speeds drop while rapid transit has frequent and time consuming stops. A distribution loop or network could connect with peripheral bus stops, rapid transit stations, taxi ranks, parking buildings and lots and intercity transport terminals. The high frequency of these small (2-4 passenger) units coupled with the possibility of passenger control directing them to the required destination and bypassing intermediate stops, provides one of the few examples where radically new technology could be economically applied to the benefit of city centres without restricting automobile use. Evaluating the economics of such a system requires more than a cost to fare income comparison. The savings to the transit system and the reduction of congestion must be realistically costed.

Canada with its limited possible applications is unlikely to be in position to afford the development costs of a SCC. Thus the development in the USA will have to be followed and arrangements (such as manufacturing licences) sought to adapt the system to Canadian use.

4.3 The Automobile

An immense number of cars are manufactured around the world, as a result, engineering development and market research has evolved a wide variety of vehicles for numerous divergent applications. Despite the wide choice of vehicles the majority of cars in Canada as in the USA are large high powered units, more appropriate for the long highway trip than for the short urban journey which consumes 43% of all mileage driven. Consumer demand has increased the number of small cars (usually foreign imports) to some 15% of the market of which a significant number are second cars. Continued freedom of choice will result in little change in this situation. The percentage of small cars will grow but not to the extent of improving urban traffic flow or parking shortage.

In certain situations, government legislation has manipulated consumer choice to the advantage of the country. For example, high purchase taxes or duty and high fuel taxes pressure the residents of many countries to purchase small cars. Bermuda is the best example of total government control. Cars are limited to one per family and cannot exceed certain dimensions. Permission to purchase a new car requires proof of disposal of the previous car either by resale or export from the island as scrap. The need for such severe control is obvious in Bermuda but would be

politically impossible in North America. Preference for small cars can be accelerated by taxing and parking pricing as discussed in section 3.2, but consumer preference can be expected to remain supreme in our free enterprise society.

The total dominance of the internal combustion engine is due neither to chance nor manufacturer's insistance. There is always resistance to change particularly with the high investment in capital plant for engine manufacture, but this cannot disguise the advantages of the high power to weight ration, and ease of refueling possessed by the internal combustion engine. Pressure by concerned bodies has finally resulted in government legislature that will steadily reduce automobile pollutants. This problem as well as the electric car is discussed in section 5.1.

Technology will have little effect on the fundamental form of the automobile, it will, however, affect its operation. Mention has already been made of existing computer traffic control in which Canada (Toronto) has been a pioneer. There is little excuse for not implementing similar schemes in all large urban areas along with other electronic aids that improve traffic safety, street efficiency or in many cases both. These vary from simple demand actuated traffic lights to free flow speed indicators and expressway ramp control that assists in inserting cars into gaps in traffic. The seeming inability to implement existing proven technology in urban areas is a sad indictment of municipal politics softened by the recurring problem of inadequate municipal finances. It accounts for this writer's long time scepticism on the possibility of major technological improvements in urban transportation.

Future technology will make possible automatic control and guidance of cars. Experimental schemes have been demonstrated in the U.S.A. but the refinement and implementation of such schemes will require an extensive gestation period and any initial operation would almost certainly be on intercity freeways.

Concepts have been proposed to operate private cars on urban guideways either on their own wheels or on self-propelled pallets. Such schemes are sheer nonsense, and make less economic sense than the small car concept on exclusive guideways. Efficiency is still related to the deadweight that is required to move each individual and Table 10 provides an approximate comparison.

Table 10 - Urban Transit Modes. Weight per Passenger

Large Car (average occupancy 1.5)	2,800 lbs.
Small Car (average occupancy 1.5)	1,350 lbs.
Small Car Concept (average occupancy 2)	750 lbs.
Urban Bus (average occupancy 18)	700 lbs.
Rapid Transit (average occupancy 40) (Toronto)	360 lbs.
Rapid Transit (average occupancy 25) (Montreal)	1,050 lbs.
Commuter Railway (average occupancy 60)	2,000 lbs.

One of the urban transport problems is that each automobile commuter carries some 2000 lbs. of steel and glass with him then proceeds to deposit this 200 cu. ft. device for the duration of the day on the most expensive real estate in the city. An advantage of public transport including most of the new concepts is that the necessary deadweight continues to recycle around the urban area devoid of expensive storage problems.

4.4 Bus Technology

Surface transit in Canada has evolved from the horse car to street-car to trolley coach to diesel bus. At one time, it could be taken for granted that surface transit would become exclusively operated

by diesel buses, however, the relatively low electric power rates in Canada have resulted in retention of many trolley coach systems in contrast to the U.S. and U.K. where few remain. Recent concern over the environment favours the trolley coach with its lack of pollution and noise. Toronto has reversed the abandonment trend and ordered 200 new trolley coaches fitted with rebuilt electrical equipment, but this decision was based on economic rather than environmental reasons. TTC found operating costs comparable but storage costs were less for trolley coaches as they can be kept outdoors through winter.

Vancouver has a major trolley coach network and has incentive to retain this on the basis of the Toronto decision, but without the streetcar and subway network with which to share the power conversion and distribution costs, it is a mute point whether it will or not. The trolley coach systems in other cities can be expected to convert to diesel buses in this next decade. The diesel bus will thus continue to be the overwhelming mode of public transit carrying over 80% of all passengers now and into the foreseeable future.

Despite this dominance the North American market for urban buses is small. U.S. requirements are for slightly over 2000 buses per annum and Canadian requirements average under 300 per year. Such volume is neither conducive to production line operation nor any incentive for research or development. Over the last decade, many small bus manufacturers have gone out of business leaving General Motors with an almost total monopoly of the market. The

exception being the Flxible Company in Ohio which assembles urban buses using GM engines and transmissions and Western Flyer Coach of Winnipeg which has recently entered the market on the same basis. GM's monopoly (some 95% of all units) is not necessarily bad, as it has rationalized the market to a small range of standardized buses. However, some transit undertakings understandably resent being locked in to one supplier and hence the survival of Flxible and Western Flyer, and the import of several batches of buses from two Japanese firms, from Britain and from Germany. All these imported buses have gained a poor reputation for reliability and maintenance difficulties and it appears that such experiments will not be repeated.

General Motors manufactures all its U.S. units in Pontiac Michigan and assembles its Canadian units in London, Ontario predominantly from U.S. components. The development of its large buses appears to have reached a limit in size and power and the next step is a major one with the introduction in 1973 (possibly later in Canada) of its XRT* model. An experimental version of this model is presently being demonstrated. The bus has hydraulic suspension which permits the bus to "kneel" at stops, so reducing the height passengers must climb. This is particularly important with the increasing off peak proportion of elderly people who have often found access and egress to buses prohibitively difficult. The XRT bus also features a gas turbine drive providing greater power with less noise and less pollution. Inevitably, the cost will be

* XRT stands for Experimental Rapid Transit

much higher than the conventional TDH* bus, presently costing just under $40,000. (Smaller versions of the bus are less.) Many operators can be expected to continue with TDH units or press for an XRT unit with the cheaper diesel propulsion. Air conditioning is a common extra on U.S. buses but has not appeared on Canadian urban units.

Development of other bus technology has been limited to several small experiments. AC Transit, a progressive California operator, is using a home built articulated bus and similar designs are common in Europe. They provide extra capacity while minimizing the road space needed for turns - a problem with the large TDH buses. AC Transit is also involved in the development of a steam bus, but this, the electric storage bus and the energy storage (flywheel) bus, will not be competitive with either the TDH or XRT buses. The hybrid bus (34) while interesting also appears to have very little potential.

This discussion has involved urban transit buses, and it should be noted that larger markets and wider range of manufacturers exist for intercity buses, school buses and minibuses.

As technological advances will make little impact on urban bus operation and maintenance and utilization of buses in Canada is probably the most efficient in the world, any major economies in bus operation are going to come from the operational side. The urban can have considerable operational flexibility particularly when equipped with radio communication. There is a need to fit

* TDH stands for Transit Diesel Hydraulic

the pattern of bus service more closely to passenger demand and work has been done on optimizing bus networks (35). Aspects of which have been put into practice in Wallasey England.

Better service can obviously be provided by smaller buses on more frequent headways but labour costs prohibit this. Carrying this concept to the extreme, results in public transit vehicles the size of private cars operated automatically over most of the journey on private "guideways" and manually driven on existing streets. Several proposals for such a scheme are discussed later.

Congestion can wreck havoc with the best organized bus schedules and transport operators try to prevent city centre delays creating erratic timing in the suburbs. This is difficult in large conurbations and an alternative is to provide shorter bus routes with interchange points. The urban and suburban parts of a service are then independent and less subject to irregular running. This also permits each section to provide service for differing demands. The concept of transfers (i.e. a single fare for a multi-service journey) is common in Canada but represents an inconvenience to the passenger.

Having determined an optimum bus network it remains to schedule service, vehicles and staff. The efficient combination of these three variables is exceptionally difficult and needs considerable skill and experience. Attempts to devise a computer program for this task have not been particularly successful but work is

continuing, reference (60) has papers on operational research for buses, in both network planning and scheduling. Mention is made of the U.S. work undertaken by Elias at West Virginia University.

The interaction between bus routes has always been an important aspect calling for the scheduling of connecting services and the even spacing in time of services that share the same route for part of their journey. The need for increasing efficiency in the utilization of vehicles and crews unfortunately causing frequent infringement of these concepts of passenger convenience.

Changes in buses, in fare systems, in networks and in scheduling may bring increased efficiency but it does little to help increase the mobility of public transport in today's congestion. Most of the suggestions to do this are obvious and some of them have been put into operation, but again there is controversy and often strong protests by other road users at the concept of giving priority to public transport vehicles, however logical it may be in the interests of overall efficiency. Buses can be permitted to make turns prohibited to other vehicles, they can have special provision at traffic signals and even carry small transmitters to operate signals. Bus pull-offs are common, less common is the total reservation of certain lanes. A limited number of reserved lanes are being used in U.S. cities in London, Paris and Stockholm. These latter two schemes are discussed in reference (33) "Improvements and Innovations in Urban Bus Systems", and it is apparent that there is controversy over

the use of bus lanes particularly where the volume of buses is insufficient to make efficient use of the reserved lane. This would be a typical situation in Canada.

More extensive preferences occur in some continental cities where trams and occasionally buses have an absolute right of way and motor vehicles are prohibited to travel on the street lanes by trams. This has been carried to a conclusion in Bremen Germany where the entire city centre is prohibited to cars and reserved for pedestrians and public service vehicles with access by delivery vans at certain hours. Other cities are contemplating such segregation with its ensuing requirements of a ring road, parking and public transport city centre feeder and distributor services. Less obvious preferences for buses are illustrated by the rule in Philadelphia where buses pulling away from stops have absolute priority to enter the traffic stream.

The use of reserved lanes on expressways has been restricted to a small number of special circumstances such as the use of one lane of the Lincoln tunnel in New York during rush hours or the provision of bus exits and entrance lanes. However Washington DC has recently opened an interstate expressway with the two middle lanes exclusively for buses and there are several other proposals presently under study. Compared with the adjacent expressway lanes, clogged with rush hour traffic, the bus lanes are grossly underutilized. Although the bus travel times have decreased by 9 to 18 minutes, the overall efficiency of this scheme is at the best tenuous. General Motors has proposed a similar concept called "Metromode".

Standard city buses would be operated on exclusive two lane roadways connecting the CBD with the suburbs, using city streets for distribution at either end and thus providing faster "Single Mode" journey for most passengers (36). GM's data shows an economical operation with a capacity up to 60,000 ppphd. As this requires buses operating at 55 m.p.h. with headways closer than their braking distance, the safety is questionable and the manpower requirements vast. Proposals to automatically space the buses and couple them together to reduce the number of drivers are possible. Work has been done in the U.S.A. and U.K. on automatically controlling, spacing, and steering motor cars on a specially equipped highway but while technically feasible, problems of finance, of compatibility with unequipped vehicles and the questions of multiple ownership and legal responsibilities have placed this on a list of events that are desirable but unlikely to happen (37). In any event, GM's proposal for connected buses on private right of way has reinvented the urban railway.

One of the new developments in bus transit which holds considerable promise is the demand responsive bus. A program sponsored by the U.S. D.O.T. at M.I.T. (55) has spent over one million dollars investigating this concept. Buses, particularly outside peak hours, often carry few passengers and the concept calls for such buses, either transit buses, minibuses or taxis to be diverted from fixed routes and under the control of a computer pick up people at their doorsteps. The intending passenger will have telephoned a centre stating his origin, destination and desired time of departure. Initially, an operator will key this

data into a computer and a despatcher will direct the demand responsive buses with a radio link. The investigators hope that with the growth of electronic touch tone phones, the passenger will be able to key his request directly to the computer and the computer in turn will respond directly to a print out device on the bus.

Obvious restraints have to be imposed to prevent passengers already on the bus from incurring too devious a journey. The cost of such a service is controversial, the optimists feel it will cost somewhat in between a bus and a taxi cost, while pessimists consider the cost will be at or above taxi fares and will hence make such a service unviable. Another problem is that the low income people who would benefit from such a service and particularly those on welfare are frequently without telephone service, or alternately would find it difficult to convey the exact information needed to make the service work.

The location of demand responsive buses would have to be known at all times and several techniques have been proposed to permit this. Such location devices could also be valuable for regular transit buses, permitting transit despatchers to detect and possibly correct delays.

Less complex versions of demand responsive buses are already in use in certain cities. GO transit has an experimental "dial-a-bus" service feeding the GO trains at Pickering Station east of Toronto. The service has been well received and appears successful

but is heavily subsidized. Contract buses are used to collect passengers from their homes at specific times and convey them to a factory or CBD. Jitneys, which are now rare in North America can be licensed for specific routes and areas to provide a low cost taxi ride.

Problems in bus transit involve a minimum of technological innovation. In concluding this section, it is desirable to stress that we are talking about transporting individuals who belong to an affluent society. People are less willing to search out the possibility of using a bus when they have alternate choices, and unless you are a regular transit user it is often extremely difficult to find out where and when transit runs. The high standard of Canadian public transport does not excuse the low level of promotion and public information. Easy availability of clear maps, uncomplicated timetables, extensive use of bus stop signs with full information of the service available, bus shelters, radio, newspaper and billboard advertising will all serve to improve the image and increase the patronage of public transport.

4.5 Rapid Transit Systems

Urban rail transit has been with us for a long time and is without doubt the simplest, most common form of rapid transit. It suffers from an old fashioned image accentuated by the quantity of vintage rolling stock that still rattles around in many cities, yet in a plethora of studies ranging from Tokyo to Rotterdam to San Francisco, its superiority over all other concepts for serving high density passenger volumes has been repeatedly validated. Alternative concepts, particulary the several monorail schemes promoted in the fifties have been soundly defeated, while the more logical concepts such as the French rubber tyred metro and the Westinghouse Transit Expressway have not received much acceptance due to their inability to demonstrate either better service or lower costs. The Transit Expressway system (38) is an attempt to provide automated multiple-unit electric buses at lower capital costs and is possibly applicable as a means of serving lower density corridors.

Canada has two subway systems in Toronto and Montreal, both with expansion plans. Compatibility with the existing subways will greatly restrict the possibility of technical innovation. Both

the Toronto and Montreal systems are regarded as models for North American systems and their cleanliness and efficient operation continue to impress the many visitors. Toronto with its undistinguished architecture operates modern rail transit cars after an unfortunate first choice of underpowered British units. Montreal has wedded itself to a complex, expensive rubber tyred system developed by the French and its patrons will be paying bitterly for this decision which was made against the advice of the consultant retained by the city. Mitigating this is the distinguished and often brillant architecture and design which has set new world wide standards for public transport.

Other Canadian cities (Vancouver (61) and Calgary) are investigating rapid transit, while Edmonton is preparing to construct a system using existing railroad alignments. This latter scheme appears premature in light of the location of the right of way and the projected traffic volumes. Rail transit, in contrast to a labour intensive bus operation should be a capital intensive system. Much of the capital cost is involved in the civil engineering works that provide rapid transit with its main attribute: an exclusive right of way giving unrestricted mobility directly into the heart of urban areas. Research and analysis into rapid transit has rightly been concerned with reducing the civil engineering cost as well as improving the equipment and optimizing the systems operation.

A transit alignment can be underground, on the surface or elevated. A surface right of way will always be the cheapest to construct

and will vary little in cost whatever the system. Non-availability of land often prohibits surface rights of way in urban areas and the common alternative is a tunnel. Here the cost is proportionate to the cross-sectional area and hence the very small profile of the London tube lines (as distinct from the L.T. surface lines). There is little prospect of reducing cross sections below this and many transit operators justify larger tunnels because of the economics and higher capacities available with the larger transit cars. An example of costs is given by Stuart who has developed the approximate formula (38):

Cost per linear Foot in U.S. Dollars (1966) for rock

$$\$\ 184 \quad \$4.00(ID) \quad \$6.75\ (0.5\ ID \quad 1.5)^2$$

where ID is the internal diameter of the tube in feet.

Table 11 gives examples of applying this formula. The costs of track structure, power and communication are not included.

<u>Table 11 - Tunnel Costs</u>

Inside Diameter	Cost/ft. of Single Track in $U.S. (1966)	
	Earth	Rock
14 ft.	818	727
15 ft.	922	792
16 ft.	1,048	857
17 ft.	1,190	927

To avoid these costs and where land is not available for a surface alignment increased attention has been given to elevated structures. A cleanly designed structure with quiet transit

equipment can often be incorporated into a neighbourhood given careful urban design without serious detriment to the environment. Considerable passenger preference is indicated for rapid transit from which there is a view. Costs here are dependent on axle loads (P lbs.) and the results showing the optimum span lengths are incorporated in Figure 7. The difference for various axle load are not as large as some promoters of lightweight systems claim but nevertheless show an incentive to move towards lightweight equipment. Reduced axle loads also reduce the cost and maintenance of the track structure, be it elevated, surface or underground, while reductions in total equipment weight will save power consumption. Cost differentials between elevated and underground construction in Figure 7 and Table 11 are self evident. Note that both are for single track only.

Rapid transit systems have to be designed individually for each urban area, and it is not possible to design or cost a system as if it were made of standard pieces of "erector set". However, the range of costs are shown in Table 12. Comparisons with this Table can be made for recent construction in Canada.

Toronto's four mile Yonge extension is estimated to cost $79 million or around $20 a mile. The projected extension, a further 1¼ miles to Finch, is estimated at $31 million or $25 million a mile. New cars for Toronto will cost $155,000 each while comparable prices in the U.S. with a more luxurious interior and air conditioning range up to $200,000.

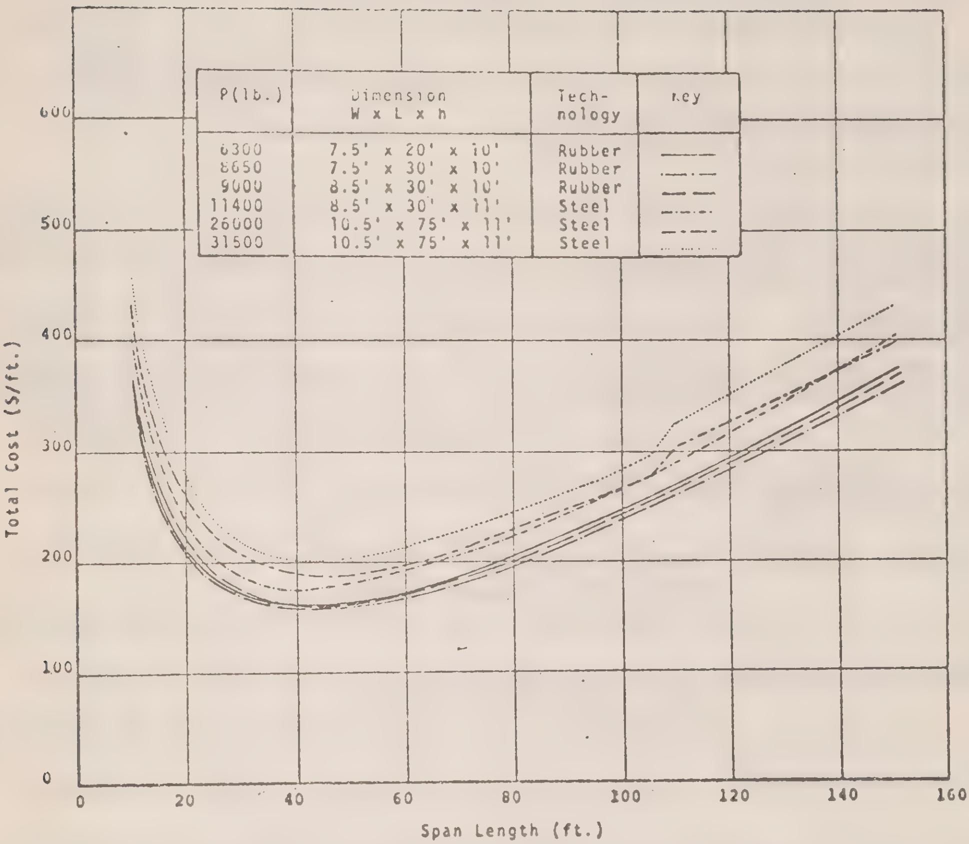

Figure 7 - Cost in US $ per track foot for single track elevated structures under various axle loadings. (P lbs.)

Table 12 Representative Rapid Transit and Road Construction Costs

(1969 Prices)

(De Leuw Cather & Company of Canada Ltd.)

ITEM	ORDER OF COSTS ($1,000,000)
1. Rapid Transit 2-track section - capacity up to 30,000 passengers per track per hour:	
Elevated structure	4.0 to 5.0 per mile
Ground level construction	1.5 to 2.5 per mile
Underground construction;	
Tunnel earth	11.5 to 15.0 per mile
Tunnel rock	4.5 to 7.0 per mile
Cut-and-cover - off-street	9.0 to 11.0 per mile
Cut-and-cover - on-street	12.0 to 14.0 per mile
Stations	1.0 to 2.5 each
2. Roads - capacity about 2000 vehicles per lane per hour:	
Six-lane freeway (roadway capacity - 6000 vehicles or about 9000 people)	2.0 to 2.5 per mile
Eight-lane freeway (roadway capacity - 8000 vehicles or about 12,000 people)	2.5 to 3.0 per mile
Major interchange	5 to 10 each

Rapid transit costs include: basic structure, tracks, power and signals
Roadway costs include: basic structure and road surface.

Note: Costs shown do not include major utilities relocation and right of way.

Right of way costs in built up areas are a major cost factor and can be significantly less for transit. Minimum right of way requirements for transit vary between 20 and 30 feet, depending on the vertical location of the line and the type of system selected. A six-lane expressway would occupy a right of way of 120 feet.

Montreal paid $213 million for its 16 mile subway or $13.2 million per mile, including its cars and attractive stations. The cars cost $45.5 million and station ranged from $10 million for Berri-De Montiguy at the intersection of 3 lines to $315,000 for Jarry.[1]

Foreign construction is experiencing similar high costs. The Paris East-West regional express line opened in 1969 cost $120 million for 13 miles, or $9.3 million a mile. The Rotterdam metro opened in 1968 cost $18 million a mile including cars and stations. Early contracts for the Washington, D.C. metro have been let with one section of the tunnel costing $45 million a mile including the excavations for two stations.

These high costs provide the incentive to utilize existing and hence cheaper rights of way. Many cities have underutilized railroad lines and this has been the basis of the Edmonton system for which phase one is estimated to cost $14.8 million for 5½ miles or $3.4 million per mile.

Rail rapid transit is a well-developed science although it can be said to have languished for many years and has only in the past decade seen significant technical advances. Even these advances have had difficulty in becoming established among some of the more conservative operators, possibly because it is not easy to balance long term improvements against the additional capital cost. In the civil engineering, technology has been

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1 Costs have been obtained from a variety of sources which are not referenced nor are they necessarily directly comparable. Except for Canadian cities all figures are U.S. dollars.

and is closely connected with the railways. The main advances being the reduction in running noise and vibration resulting from continuously welded rails, rail mounting pads, and automatic equipment for maintaining rail alignment and smoothness. Acoustic absorbers have been developed for tunnels, stations and curves to control noise level. Coupled with resilient wheels, jerk free traction control, improved suspension, and acoustic and vibration damping on the cars, a modern rail transit system can be exceptionally smooth and silent as demonstrated in Milan, Stockholm, Toronto and San Francisco.

Propulsion is invariably by DC motors with power usually collected as DC, although advances in solid state control equipment can make higher voltage AC collection attractive for new installations. Motors have tended to be axle hung with a direct parallel drive giving a cheap and rugged system. Numerous different drive schemes have been developed to reduce the unsprung weight of the motor on the axle with its possible consequence of track wear. These have involved a variety of flexible drives and/or right angle gearing and there is now considerable controversy over the best system with the parallel drive being favoured for urban transit. The tendency is to revert to this drive but with a double reduction parallel gearing. A West German development by Waggenfabrik Dusseldorf is the Duwag truck using a longitudinal motor resiliently coupled with right angle gearing to both axles of the bogie. A large motor can be used with the frame acting as a truck member. The

direct mechanical coupling of the axles has advantages in obtaining the maximum adhesion for accelerating and braking. The Duwag truck is used on several European systems in conjunction with a two car articulated unit, which has thus only three trucks, reducing total train weight.

To be competitive, modern rail transit must have the best possible performance, but here again there is little prospect of any improvement over the best modern equipment. Performance is specified by a trains power to weight ratio and is limited both by the maximum adhesion available between steel wheels and steel rails under adverse conditions and by passenger tolerance to the accelerating (and braking) forces. In general, this latter limitation is the dominant one. On all urban transit there will be standing passengers during the periods of accelerating and braking on leaving or entering stations, even if these are only people leaving or going to their seats.

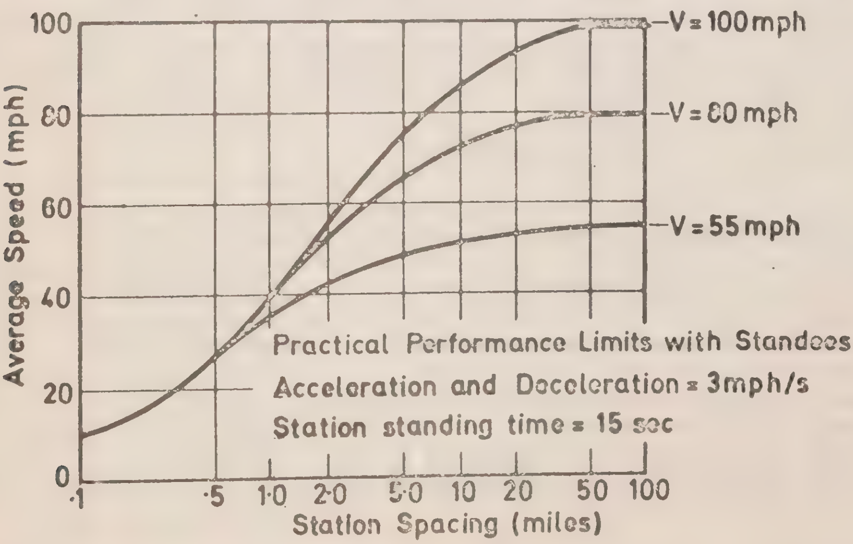


Figure 8 Urban Rapid Transit Performance.

Braking or accelerating is therefore limited to 3 mphps and this is readily obtainable over most of the performance curve with modern transit equipment. Attempts to exceed this limit with equipment such as the rubber tyred metro cars has resulted in adverse passenger reaction. This limitation means that the overall performance of a rapid transit system be it rail or not, is effectively regulated by station spacing. Figure 8 shows the average speeds against station spacing for equipment with 3 maximum speeds, 55, 80, and 100 mile/h. Consequently, there is no need for major technical changes, existing technology can already provide all the necessary performance for urban transit and however far we look into the future this is unlikely to change. Adequate power to weight ratio can be obtained with 100% motored equipment (that is with all axles powered) and this is becoming standard world wide practice. Although 100% motored equipment increases both first cost and power consumption, the higher performance reduces total equipment requirements and permits all electric braking down to low speeds, so reducing brake noise and brake maintenance. The faster schedules and smoother braking help attract passengers.

The nature of urban transit requires a dense operation that invariably justifies electrification and there is no attraction to use prime movers (such as gas turbines). Linear induction motors have been suggested as a propulsion mode. They have no moving parts and are expected to require little maintenance. Their suitability and efficiency for the moderate speeds of urban transit is uncertain. However, this technology merits a detailed

engineering and economic analysis as the increase in power consumption, decrease in power factor and higher first cost could be more than offset by the reduced maintenance and the reduced weight.

Modern technology has introduced other improvements to rail transit which are being introduced against a background of controversy, particularly where they involve a reduction in labour requirements. Automatic Train Control (ATC) is available in several forms from extensions of conventional track circuit signalling to sophisticated guided radar. Advantages are the reductions in train crew to one man where the union so permits. (Theoretically no driver is needed but operators have been unable to achieve this with the exception of the Westinghouse Transit Expressway in which there is no provision for any driver.) ATC also provides smooth operation of the train with either the fastest performance of most economical power consumption depending on the operational requirements, and so gives the maximum utilization of a route by running trains at the closest possible headway. More references dealing with labour, operational and technical aspects are given in references (39) and (40).

Propulsion and braking have been the subjects of recent technological advances in rail transit. Automatic acceleration with resistance switching has been available for many years and is now being superseded by solid state controls using thyristor choppers to adjust the input voltage to the motors without the power waste of resistors. The proven reliability and freedom from maintenance

of solid state devices justifies the higher first cost of such equipment particularly when the reduced power consumption is taken in to consideration. Although this means that there is no waste heat during the accelerating period, all the braking energy whatever combination of electrical or mechanical braking is used, is converted in to waste heat. Consequently, the higher speeds and hence higher braking energy of modern equipment is creating overheating problems where routes run for an extended length in tunnel. At one time, regenerative electric braking returned a proportion of braking energy to the power distribution system but problems with voltage surges and with the maintenance and first cost of the necessary equipment, both on vehicles and in the electric sub-stations, has resulted in regenerative electric braking being replaced by dynamic electric braking. Now it is becoming increasingly expensive to provide adequate ventilation in tunnels and a return to regenerative braking may be justified.

Modern vehicle design requires high levels of lighting and controlled ventilation supplemented in hot climates by mechanical air conditioning. There is also a tendency to move towards higher standing to seating ratios with the provision of vandal proof seats molded from glass-fibre or plastic.

The final step needed to get away from the old image of rail transit is a new name and the one that has come into vogue is "duorail". Duorail more so than most other means of public transport is a mass mover and requires large passenger volumes

to justify its capital expense. There are many urban corridors with more moderate passenger volumes where segregated rapid transit would be desirable and several "medium density" modes have been developed to fill these needs. The Westinghouse Transit Expressway (38) and the light electric railway come into this category. Developed from modernized tramway systems in Germany and Sweden is the concept of the light electric railway or limited tramway where light-weight, high performance multiple unit trams, often articulated, operate on grade separated rights of way and on streets where the latter cannot be economically provided. The right of way can be constructed section by section as funds are available and is often constructed to standards enabling it to be converted to a heavy rapid transit line should patronage grow. Vehicles are mass produced using bus and tram techniques resulting in a system with almost all the benefits of rapid transit at a lower capital and operating cost.

The advantage of the LER over the duorail is its ability to give more passengers a direct ride. Similarly a bus network can provide more direct service, and if such service can utilize an exclusive right of way for part of the journey it would become one of the more realistic possibilities for the intermediate size Canadian cities. Carrying this concept of the through trip to the extreme arrives at the motor car which not only provides a door to door trip but also has an immediate availability. Attempting to provide public transport with these attributes has produced a rash of concepts termed "small cars". The small car

concept has now ousted monorails as the "new thing" in transport. Like monorails the concepts often fail to reveal any potential when faced with the realities of their engineering and economic feasibility. Unlike monorails they have so far failed to progress into the prototype stage.

The "small car" is usually an automatic, electrically propelled vehicle with four seats. It operates at moderate speeds on a guideway which can be elevated, on the ground or in a tunnel. Most frequently the elevated mode is proposed, claiming to be economical to build because of the light axle loading. Figure 7 has already shown how structure costs do not decrease radically with axle loading. This is applicable to the lighter loading of small cars where strength and cost is more dependent on wind loading and structure weight. Most concepts provide for cars to be routed to their destination without stops at intermediate stations, using a wide variety of guidance and switching concepts. The most desirable systems permit the cars to leave the guideway at stations and be driven manually on the streets propelled from storage batteries.

The biggest drawback of all small car systems is the very limited handling capacity of a single guideway. At the typical speed of 35 m.p.h. with emergency braking at 7 mphps, a stopping distance of 125 feet is required. Adding a safety margin of 50 feet, a single guideway capacity is 1060 cars per hour or a maximum of 4000 passengers per hour. Proposals call for running cars closer together, or coupling and uncoupling cars into trains at speed.

The former does not provide an acceptable level of safety while the latter will be an exceptionally difficult and hence expensive technical feat.

This author reviewed the small car concepts in (30) including at that time these systems:

"Alden StaRRcar. The StaRRcar concept is similar to the electric rental car. It consists of small two or four passenger electric cars which can be either driven on the street system, propelled from storage batteries, or automatically controlled and steered on a guideway with propulsion from a power rail. This provides a passenger with a rented unit for single mode trip from his origin to destination via as much of the automated guideway as possible, thus approaching the ultimate in desirability for urban transit.

The Alden Self-Transit System Corporation, promoters of the concept, have built a single car and a short section of guideway but have not specified the technology needed to make the concept feasible. It is difficult to make a car capable of economical battery operation on a guideway. The concept calls for adding cars into the guideway and coupling them on the other cars moving at 60 m.p.h. There is no present indication that technology will be available to do this both safely and economically. The basic requirements in transit operation that adequate braking distances be always maintained between moving vehicles is hard to dispense with. Failure to maintain safe spacing can result in a disastrous multiple collision should a car hit an obstacle or come to an abrupt stop with a retardation greater than the emergency braking

rate of the following cars. Such multiple collisions may be acceptable for private automobiles on urban expressways, but a higher level of safety and reliability is required for public transit.

Alternatives proposed to make the Alden concept more feasible include running trains of cars that do not leave the roadway or inserting cars at input ramps already coupled into trains. These alternatives do not avoid the basic disadvantages of very limited guideway capacity, and dubious overall economics created by the high vehicle cost per unit seat. Until further extensive development eliminates these disadvantages, the StaRRcar concept does not justify serious consideration as an urban transit mode.

Teletrans. A system of small cars, automatically controlled and steered on a guideway by linear motor propulsion and air suspension.

Carveyor. Developed by Stephens-Adamson and Goodyear Tire and Rubber Company as a city centre distribution system. Passenger cabins holding from 4 to 10 people travel at 15 m.p.h. on a continuously moving rubber belt, slowing down to 1½ m.p.h. in stations where passengers board from a moving sidewalk at the same speed. Capacity 5,000 to 10,000 passengers per peak hour direction.

Telecanape. A continuously moving row of seats travelling at 8 m.p.h. Passengers enter and exit the system from large circular platforms whose peripheral speed is the same as the seats.

Access to the platform is from the centre. Capacity is 8,300 passengers per peak hour direction.

Minirail. A Swiss system of small overhanging monorail cars electrically propelled along a narrow elevated beam. This system has a capacity of 5,000 passengers per peak hour and was used as a secondary distribution system at the Expo '67 in Montreal.

Project Metran. This 1966 student project at the Massachusetts Institute of Technology has introduced several concepts in urban transportation, specifically for the Boston region.

A more recent review is contained in Appendix D of the Southern California Rapid Transit District Report, May 1968, prepared by Simpson and Curtin of Philadelphia with details of these additional conepts:

- People Mover: Four seat passive cars propelled by Fixed motors on the guideway.
- Transveyer: A conveyor with enclosed compartments for standing passengers.
- Fichter System: Two passenger cars, automatically operated on elevated steel guideway.
- Skylift: Four passenger electrically propelled vehicles, suspended from an overhead track.
- Uniflow: Six passenger vehicles, air supported and propelled from airjets in the guideway.
- Tex Train: Four passenger vehicles, electrically propelled on a conveyor type guideway.
- Monocab: Six passenger vehicles suspended from an overhead

guideway.

- Horizontal Elevator: Powered vehicles suspended from a monorail with vertical elevators for loading.
- Urbmobile: Small electric car that can be driven on street or operated automatically on a guideway.
- Supra-car: automatic electric cars operating on a steel elevated track to which access is obtaining by running up or down the support columns as a rack driven elevator.

To these concepts must be added the British development the Brush Auto-taxi, presently being analyzed with National Research and Development Corporation support. Four-passenger electric cars are automatically controlled on a guideway and in one version of the scheme can be operated manually on the streets.

Not all the above proposals are intended as full public transport systems but come into the category of city centre distribution systems such as the moving walkway and Bouladon integrator mentioned at the beginning of this section. Some of them indeed come into no category and are pure science fiction but have been included for the sake of completeness. It may be charitable to say that some of these small car concepts have long term prospects, but in the short term there are far more essential needs in public transport on which to devote the limited available funds.

5. SOCIO-ECONOMIC EFFECTS OF URBAN TRANSPORT

5.1 Pollution

Congestion if by far the most obvious is only one of the problems introduced into the city by motor vehicles. Our urban environment is being increasingly violated by noise and air pollution. The problem has reached a crisis level in several North American cities notably Los Angeles where a hot climate and frequent weather inversions decompose exhaust emissions into a toxic smog. Resulting legislation led by the State of California is steadily reducing the permitted quantity of pollution and progressively more severe restrictions will be coming into force.

Vehicular pollution consists of four components: hydrocarbons, carbon monoxide, nitrogen oxides and lead compounds, originating from three sources; exhaust omission, crankcase blowby and evaporation. Table 13 shows the breakdown of these divisions for the United States.

Table 13 - Typical Automobile Emissions

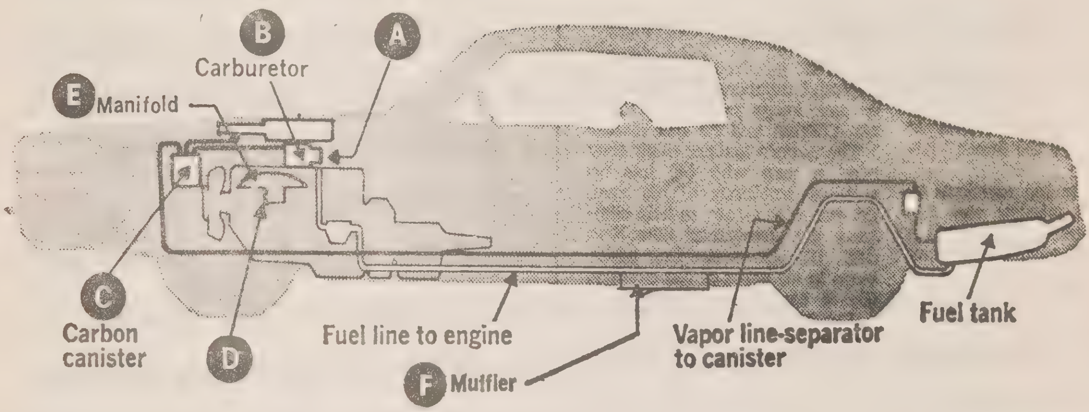
	Amount Per Car Per Year	Typical Emission Levels in Parts per Million		
		Uncontrolled Car	U.S. Standards 1968	Ultimate Possible 1980
Exhaust				
Hydrocarbons (55%)	300 lb.	990 ppm.	275 ppm.	25 ppm.
Carbon Monoxide	1700 lb.	3.5%	1.5%	0.25%
Nitrogen Oxides	90 lb.	1500 ppm.	1500 ppm.	100 ppm.
Crankcase Blowby				
Hydrocarbons (25%)	130 lb.		none	none
Evaporation				
Hydrocarbons (20%)	90 lb.	1500 ppm.	none	none
Total	2310 lb.			

The effects of lead emissions are not clear and are being studied, medical authorities (42) are worried about the cumulative effect of lead poisoning. Lead components are added to gas to increase its octane value but other compounds can be used to the same effect. The recent trend to low lead gasoline is the first stage in the reduction of lead emissions to the atmosphere.

Diesel engines produce a much smaller amount of pollution unfortunately with an unpleasant odour. Fuel additives or catalytic exhaust control can remove this odour at a price but in general the pollution from diesels is not serious and existing legislature, although difficult to enforce, prohibits an excessive exhaust emission from ill-maintained engines. Hence, buses which are often accused of polluting the city, in fact, contribute a negligible amount of pollution. Figures from the Los Angeles County Air Pollution Control District show that the 1500 buses in that city contribute 0.03% of the air pollution by weight, while all other vehicles contribute 85% to 90% of the total. The percentage in Canadian cities which have a higher bus to car mileage ration will be greater, offset to some extent by the better maintenance of buses and the higher proportion of electrically propelled vehicles. However, the percentage pollution from buses by weight is unlikely to exceed 0.1% and can be discounted as negligible. Extensive work in the United States has produced a variety of devises that will reduce vehicle pollution to an acceptable level (42) (44) (45) illustrated in Figure 9 (43).

To Reduce Car Pollution

Figure 9



Tougher exhaust standards for automobiles, to be applied on 1973 and 1975 cars, were a major part of the antipollution program announced last week by President Nixon. Some of the auto industry's antipollution devices are illustrated above. A: PCV valve, or positive crankcase ventilation system, designed to remove unburned gasoline from the crankcase. B: CCS, or Controlled Combustion System, involves controls for mixing air and fuel and modifying ignition timing. C: EEC or Evaporative Emission Control, involves a series of pipes between the carburetor and fuel tank and a carbon canister to store fumes. It is on 1970 cars sold in California and will be on all 1971 cars. D: TCS, or transmission controlled speed. It retards spark timing to control nitrogen oxides and hydrocarbons. E: Reactors, or some form of afterburner to consume exhaust gases. F: Catalyst-muffler, a device that will oxidize unburned fumes. The first four systems are estimated to cut 80 per cent of hydrocarbon and 66 per cent of carbon monoxide emissions. E and F devices will probably be introduced to comply with the President's 1975 deadline.

Makherji (46) suggests that statutory planning can set an acceptable limit for the density of motor vehicle operation in urban areas, so keeping pollution to an acceptable level. This would effectively prohibit expressways in an urban environment and seems an unnecessary restraint. The alternative of emission control is probably more practical. U.S. requirements legislate the maximum pollution levels of new cars which are relatively easy to measure and enforce, far more difficult is to ensure that the levels are kept low, by periodic inspection. A six monthly inspection of all cars is in force in several states and this can be extended to cover levels of emission. In Canada, considerable changes in the diverse provincial testing procedure would be needed to enforce pollution control. The main problem is cost. The anti-pollution devices add capital cost to the car and reduce engine efficiency. This makes the devices difficult to fit to small cars which already have a low power to weight ratio, and the extra fuel consumption adds a large amount to the nation's transport bill.

Estimates have been made in the U.S.A. of the total cost of pollution to the nation from erosion, crop damage, loss of time or death from disease directly related to pollution and loss of property value in heavily affected areas. Although difficult to quantify, experts feel that a figure in the region of $1.3 to $1.5 billion dollars a year is correct. Scaling this down to Canada in relation to the population, in relation to the proportion of pollution contributed by cars, and in relation to the number of cars we arrive at a figure of just over $100 per car

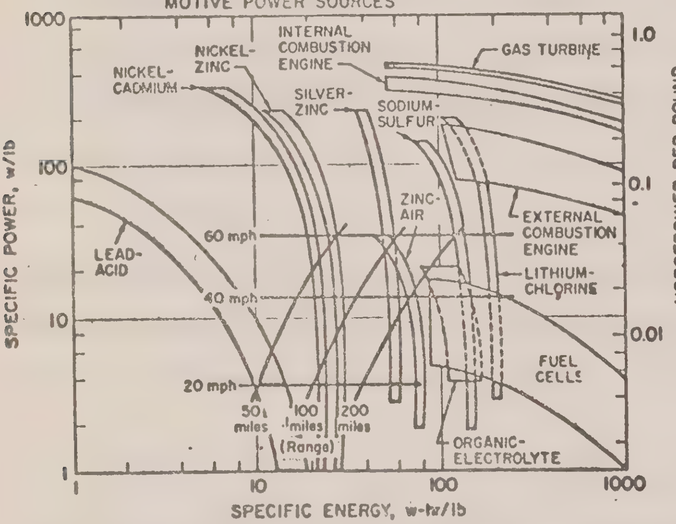
per year. As the average car uses $300 of gas per year, pollution devices could be justified in reducing the efficiency of each car by 25% (i.e. from an average of 15 mpg to 11.25 mpg). However, a realistic cost benefit analysis must be more complicated than this.

Although acceptable pollution control can be achieved in internal combustion engines, there has been an incentive to encourage alternative propulsion forms for motor vehicles. The United States led the field with several extensive studies in 1965 and 1966 of electric cars (42) (47) (48) of which this writer made a survey in 1967. There is presently no indication of an electric car being available that will make it competitive with the i.c. car from a standpoint of either cost to power, or cost to weight ratio.

Figure 10 illustrates the specific power and specific energy of a variety of propulsion modes. Neither the more exotic (and expensive) storage batteries such as silver-zinc, sodium-sulphur or lithium chloride, nor fuel cells can match the i.c. engine in performance at an acceptable weight. Cost further eliminates these devices from serious consideration in a production car. The gap is so vast that there is no indication of a future breakthrough that will make these devices commercially feasible. Consequently, recent effort has been directed at combustion engines with ingerently low amounts of pollution. External combustion engines burn fuel at or close to atmospheric pressure ensuring an almost complete combustion with little pollution. Two engine

cycles, the sterling engine and the steam engine have been investigated. The heavier weight of a modern steam engine can be partially offset by reductions in gears, clutch, and transmission, and fuel efficiency can match the i.c. engine. Results have indicated that the modern steam engine is unlikely to be a successor to the i.c. engine.

FIGURE 10 VEHICLE REQUIREMENTS AND MOTIVE POWER SOURCES*



*Assumes 2000 lb vehicle, 500 lb motive power source and steady driving. Power and energy taken at output of conversion device.

Electric cars may not appear practical to supersede i.c. cars but the use of solid state control coupled with cheap lead acid batteries can produce a town car at a moderate price with speed capabilities of 40 mile/h and a range up to 60 miles. There may be a limited market for such a vehicle and several manufacturers are producing small quantities in Britain and the U.S.A. However, they pose no threat to conventional cars and their number are so few as to promise little relief from pollution. The cars are usually fitted with a charging unit and can be

recharged from a domestic electricity supply advantageously in the evening of an off-peak tariff. Ironically, the majority of electricity in Britain and the U.S.A. is generated from fossil fuels, so contributing indirectly to air pollution. In fact, steam generating plants burning soft coal are a more serious pollutant than the automobile as the sulphur dioxide content is high and this forms sulphuric acid with destructive results to man and materials. In Canada, 71% of electricity is generated by water and although this percentage is falling, it is a long way from the 12% in the U.S.A. and an even lower figure in Britain.

Battery electric cars are not a new development, but a recent advance for these is the availability of cheap thyristors. Thyristors eliminate power waste during acceleration and permit regenerative braking to return power to the batteries. The range of small electric cars can only be extended by using higher capacity batteries but lead-acid batteries are too heavy while the more exotic batteries are too expensive. An alternative is the hybrid car in which a small combustion engine with almost no pollution - an experimental car uses an 8 bhp Sterling engine - floats on the batteries. Acceleration takes the power both from the engine and the batteries, thereby extending both the speed and range of the car. As with other electric cars there is inadequate power for mechanical air conditioning but the Sterling engine can help in heating the car. The equipment on such a hybrid car is more complex, heavier and more expensive than a conventional electric or i.c. car. The hybrid car does present more potential for large scale use in

the moderate future, but its potential is dependent on more development and the necessity of eventual mass production. Whether this ever takes place cannot be determined until current studies on hybrid cars and steam cars have been completed.

Legislation has been suggested to restrict travel in certain urban areas to such electric or hybrid town cars but this does not appear feasible. The electric car is easy to drive and maintain and less subject to driver abuse. Suggestions have been made that they would make suitable rental cars at suburban and urban rapid transit or commuter rail stations, freeing many families from the need for a second "commuter" car which usually covers only short trips. This situation is currently more applicable to the U.S. than to Canada but it is difficult to see that it would be economically feasible in either country.

In conclusion, despite wide press coverage of the many new car concepts, the existing i.c. car reigns supreme and may be expected to do so for a long time to come. There is no indication that any major technical breakthrough will change this situation. Canada must now follow the United States with ruthless legislation to make the i.c. car as safe, as quiet and as pollution free as is reasonably possible. Equating, admittedly with difficulty, the extra cost against the improved environment.

5.2 Poverty

This report can present only a broad outline on the problems of poverty and transportation, based on U.S. data. The 1964 U.S. data on car ownership is probably close to the 1974 Canadian situation.

In the course of opting for an automotive civilization, which provides unprecedent mobility for those who can take full advantage of it, the national majority has chosen to ignore the problems this civilization creates for those who have not. Public policy has massively reinforced the tendency of consumer choice in favour of the automobile to open up an ever-wider "mobility gap" between those who have and those who lack regular access to a car (49).

Public transport provides mobility for those without access to cars only when it is available, when it is not too expensive and when it is within the potential users capabilities. Many people fall into a class where they have no access to transit, are too poor or too handicapped to use it. The report "Latent Demand for Urban Transportation" (50) investigates this problem, its extent and possible solutions.

In 1964, 23% of U.S. households did not own a car, while 35% of the households in urban areas had no car and 46% of households with incomes below $3,000 had no car. 48% of the households, headed by persons over 65 had no car. Furthermore, of the 60% of the population over the age of twenty, 24% were not licensed to drive and of the 40% under twenty, 88% were not licensed.

That is, 49.6% of the population did not hold drivers permits. When half the population cannot drive the automobile cannot claim to provide "unprecedented mobility". Admittedly, many people are provided with mobility as a passenger, but there are many restraints to this, particularly for one car families.

Is this situation any different from earlier decades? Before the advent of the car, urban mobility was dependent on public transport and walking - hence the compact cities. Most dense urban areas still have and will continue to justify public transit service. It is the urban sprawl made possible by the car that cannot support adequate public transport. People living here knowingly deprive themselves and their dependents of public transport and must undertake the chore of driving their children and the expense of school bus service. They should not expect public transport cross-subsidized by the denser areas but can have public transport if directly subsidized by the suburban community or paid for by higher user charges such as zone fares. People who know they are dependent on public transport must live in areas that can continue to be viably served by it. This is an unfortunate but necessary restraint.

It is regrettable that the location of low rent public housing, homes for the aged and certain public buildings such as hospitals, (sometimes financed with Federal funds), do not always take into account their accessibility by good public transport.

In large cities, there should be little problem in retaining adequate if limited mobility for those without cars. In small

cities where public transport will eventually disappear, those without cars will be restricted to walking or taxis and the community will bear the cost of school bus services. This decline in public transport has already reduced rural areas to total dependence on the automobile.

The implications above are that the poor; if they want mobility must move to the denser urban areas. This, in turn, presents difficulties because it increases the social and welfare problems in an already overloaded area. Furthermore, the urban poor are dependent on the extent of the transit system and thus do not have the same job opportunities as the more mobile.

The very poor and the handicapped cannot use public transit even if they live in an area where it is available. There is no obvious solution, although just as children and the elderly (in many cities) get reduced fares subsidized either by the community (desirable) or other transit riders (undesirable), so people on welfare can be provided with free or subsidized tickets.

For the slightly handicapped and the less mobile elderly, an attempt must be made to design transit vehicles, subway stations and other transportation facilities to accommodate them wherever possible (51).

5.3 Crime

> **BUS PURSUIT**
>
> VIENNA (AP) — A man who became angry when a city bus didn't stop for him hired a cab, chased down the bus, climbed aboard and assaulted the driver of the moving vehicle, police reported. The bus crashed into a ladies' boutique.

As the usage of public transport in the United States has declined towards an all captive market, off-peak usage has tended towards the lower social classes. Couple this with the growing urban lawlessness and there has evolved an unfortunate increase in vandalism and crime. Modern youth can still wield a penknife on seats and technology has provided him with felt markers and aerosol paints that are put to all too frequent use on transit vehicles. As a result, U.S. operators are fighting a continued battle with litter, dirt and vandalism. Upholstered seats are being replaced by the less comfortable, moulded fibre glass units. Broken windows are a common sight on some large city systems and certain operators (for example, Philadelphia and the Long Island Railroad) appear to have given up the battle to replace windows.

Transit operator robberies and occasionally murder have forced or prompted over 50 major U.S. systems to revert to an exact fare plan. Operators carry no change and fares are inserted into a locked drop box. Although this appears inconvenient, it is really no more so than the pay telephone or other coin operated equipment where use is contingent on having the correct combination of coins. After teething troubles, most passengers have accepted the situation. Availability of ticket books, sold in banks and stores, has also helped. One positive feature has been the speeding up of loading, Table 14 indicates typical service times.

Table 14 - Service Time Entering Buses (3)

		Seconds per Passenger
Single Coin or Token Fare	- Driver Collection	2.0 - 3.0
Odd Value Cash Fare	- Driver Collection	3.0 - 4.0
Zone Fares with Prepurchased Tickets		4.0 - 6.0
Zone Fares with Cash	- Driver Collection	6.0 - 8.0

One side effect of the crime and vandalism occurs in several cities with an operator shortage. Operators choose their runs on seniority and inevitably choose the easy runs. The vandal prone ghetto services are left with an operator shortage and hence have inferior service. In New York, the transit police force has been expanded and dogs introduced in an attempt to reduce crime. Train consist is not normally changed during the day, but now in the evening certain cars at the rear of the train are taken out of service (although still hauled around). Passengers are thereby forced into fewer cars and it appears that the presence of other passengers - even apathetic New Yorkers - reduces the possibility of muggings and rape.

This grim picture has not permeated into Canada. There is vandalism, but the high standard of maintenance corrects this rapidly and removes the incentive or excuse for further vandalism. The wider usage and public ownership of transit also contributes to the low vandalism. There have been a small number of operator robberies but exact fares have been introduced only in Vancouver and there are no indications that any such move is planned in other cities.

It is hoped and probably true that the Canadian urban society will not deteriorate to the level of lawlessness found in the U.S. However, there is no place for complacency and the design and operation of existing and new transport systems must attempt to discourage vandalism and crime.

6. PUBLIC TRANSPORT AND NEW DEVELOPMENT

6.1 Urban Redevelopment

Large scale urban redevelopment can be planned to incorporate efficient public transport. Communities can be developed at densities that will support excellent transit service and facilities provided to run this service at its most efficient. It becomes possible to separate the automobile from pedestrians with an entirely separate internal distribution system.

One problem with innovation in transport is that changes have to be grafted onto the inherited systems, often resulting in severe constraints. Urban redevelopment can remove some of these constraints. Transport facilities should not therefore be added to the redevelopment plans, nor should the redevelopment be grafted onto the existing transport system. Redevelopment should be planned around an optimum transport network.

6.2 New Communities

An alternative to the urban sprawl is the planning of total new communities which although independent of a city should be within commuting distance. Examples of such planning are the several satelite communities outside Stockholm, built on and around the extremities of the subway network. The form of such communities as Fruangen, Farsta Strand, Vallingly, Hasselby Strand, Hagstra and Bagarmossen depends on strong central planning (the term autocratic has been used) and involves a mix of high and medium density housing for a range of income levels.

The desperate shortage of housing in Sweden tends to ensure the success of these communities but they are not overwhelmingly popular with the residents.

In England, new communities have been developed as new towns intending to be entirely self-sufficient in both housing and employment. Established under the strong socialistic central planning, they have not been entirely successful. While such new towns are unlikely in Canada, the concept of a satelite community could be attractive. Such communities tend to attract the higher income people who are already totally automobile oriented, making it difficult to provide any economically viable intra community transport. However, a high speed link into the main city is a possibility and in fact would be a necessity if the distance was beyond tolerable automobile commutation. The Canadian Transport Commission has been investigating intercity transport and applicable technology in a recent project "Inter-city Passenger Transport Study" (56) (62). It is possible to operate high speed trains up to 150 mile/h. and Tracked Air Cushion Vehicles (TACV's) up to 250 or 300 mile/h.

A rough analysis follows to indicate the size of a community necessary to support a TACV system.

Imagine a new community population X located Y miles from a major city on an existing alignment (hydro or railway) that could be used for high speed ground transport. Y must be larger than a convenient commuting distance.

$$Y > 30 \qquad \_\_\_\_\_\_ \ (1)$$

The TACV system will cost an average of \$1.35 million/mile plus \$10 million for terminal facilities and special construction in the urban area. Operating cost will be about 2.5¢ per seat mile based on 80 seat self-propelled vehicles.

The average family has 3.9 members so that there are X/3.9 wage earners and we will assume that 70% of these would commute to the city on the TACV system.

Number of daily riders = 0.18 X ____ (2)

Capital cost of system $\doteq$ 10 + 1.35Y ____ (3)

Levelized debt service over 30 years at 10% interest rate

$$= (10 + 1.35Y)\left(0.1 + \frac{0.1}{(1.1)^{30} - 1}\right) \quad \text{\_\_\_\_ (4)}$$

$$= (10 + 1.35Y)\ (0.106)$$

Commuting cost becomes

$$\frac{(10 + 1.35Y)\ (0.106) \times 10^{8}}{0.18 \times (600)} + 2.5Y\ ¢ \quad \text{\_\_\_\_ (5)}$$

A matrix of X and Y follows:

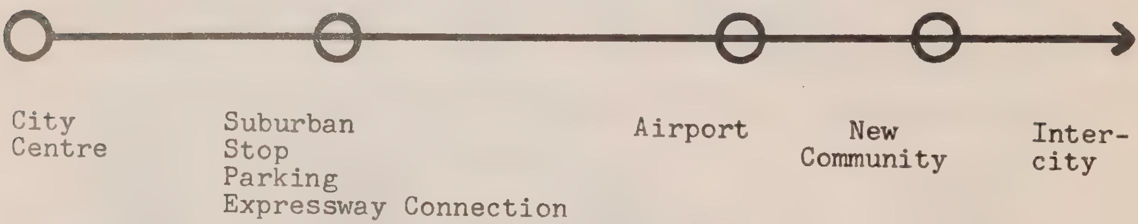
Commuting Cost Matrix (Single Journey) (1970\$)

Distance Y (miles)			
Population X	20	30	40
100,000	\$4.10	\$5.75	\$7.30
200,000	\$2.30	\$3.25	\$4.15
400,000	\$1.40	\$2.00	\$2.60
Time for Journey (not including time to and from terminals)	9 min.	13 min.	16 min.

This calculation shows that a very large community would be needed to support high speed service. It could be expected that one way fares in the order of \$2 to \$3 would be the maximum commuters would bear. Note that at 20 miles distance, many commuters would drive and the 70% usage would not occur.

Comparable unit costs are not available for high speed rail service, but a rough estimate would suggest that the cost would be 60-70% of the TACV and the journey time about double.

The matrix indicates the economic impossibility of supporting a high speed link solely to serve a new community. Similar studies have shown the difficulty of supporting a high speed link solely on airport traffic and only marginal possiblilities of supporting a high speed intercity link. (56) However, were a community to be built on a route that could obtain additional patronage from airport traffic, intercity traffic or other suburban communities, it is possible to conceive of a viable route with fares in an acceptable range.



The above sketch illustrates the possibility of such coordination. The main disadvantage is that each stop adds 4.5 minutes to the schedule time, hence detracting from the high speed nature of the service. Station purposes are:

City Centre: Where possible, a central location in the CBD with walkways to high employment areas, and good interconnections to local transit, taxis, other intercity service. When a CBD location is impractical, a station on an existing subway line would be an alternative location.

Suburban Stop: Located on or connected to the urban expressway network with provision for extensive low cost parking. Probably the busiest station, this would serve as a principal interchange for city residents commuting to the CBD or travelling to the airport. It would serve as a terminal for intercity (TACV) and air travellers wanting to rent a car. It could be combined with major development - shopping centres, cinema, apartment and office buildings, to create an inner "new community".

Airport Stop: A specialized station with baggage handling facilities and a secondary distribution system to serve the various airport terminals. The provision of parking and car rental at the suburban station will reduce the amount of road access, the amount of parking and other facilities needed at the airport. Employment at the airport will support local housing and with the peripheral industries attracted to the airport will provide extra traffic on the TACV link.

New Community Station: This section would interconnect with any local transit that can be supported including the somewhat remote possibility of an automated distribution system. Extensive parking and planning would be required to ensure

that the station becomes the focal point of the new community with shopping and entertainment. An alternative to this radial form of development would be a linear city built along the TACV alignment. Several stations on the high speed service would be possible if the new community was a terminal point. Otherwise, a secondary transport system would be necessary to parallel the TACV line and the general indication is that intra city transport in a linear city would be unfeasible unless a high density of housing was maintained.

This concept for coordinated use of a high speed link is one of the most promising uses for new transport technology. It is particularly applicable in the Canadian corridor (Windsor to Quebec City). The problems of coordinating the planning, development and financing between so many diverse uses and diverse jurisdictions is large, but it is an area which would merit a thorough Federal government study.

7. GOVERNMENT INVOLVEMENT IN URBAN PUBLIC TRANSPORT

7.1 Canada

The Federal government has no policy with respect to the public transport component of urban transportation. The Minister of Transport announced the formation of an Urban Transportation Unit in the Transportation Policy Research Branch of D.O.T. in November, 1968. A small amount of work as well as the commissioning of a report (28) has resulted, augmented by a small interest in this field by the Research Branch of the Canadian Transport Commission. An interdepartmental committee on Urban Transportation has been formed representing the Canadian Transport Commission, Ministry of Transport, National Capital Commission, Central Mortgage and Housing Corporation, Regional Economic Expansion, Department of Finance and the Treasury Board. The committee has prepared an Inventory of Existing Federal Involvement in Urban Transportation (November 13, 1969) which includes the government's involvement in urban road projects, urban redevelopment and the elimination of grade crossing. None of which specifically involve Public Transport. It is not clear, at this time, how much involvement the newly formed Transportation Development Agency or the Department of Urban Affairs will have in urban transport.

The Municipal Development and Loan Fund has provided financial assistance for public transport projects in Metropolitan Toronto but this seems to be an isolated case. Railroad operating subsidies are partially used for certain commuter services.

Provincial Government involvement in public transport is varied and relatively minimal. Ontario has provided a proportion of the capital for the Toronto subway and has funded and will continue to subsidize the GO Transit East-West rail link in Toronto, expanding this to include express bus services. This latter project has been justified on the basis of reducing the requirements for highway construction. GO Transit is a relatively inefficient operation due to the railroad nature of the service, and each commuter is subsidized some $500 per year. As these commuters tend to be the more affluent suburbanites, this subsidy is in direct contrast to the earlier recommendations for assistance to improve the mobility of the urban poor.

Alberta provides exemption from Provincial Motor Fuel Taxes for public transit, while Manitoba provides a direct subsidy to public transit equal to the subsidy provided by the local government or 3% of the operating revenue, whichever is the lesser of the two.

Details of specific Federal and Provincial involvement in all aspects of urban transportation are contained in (18) and (24) and reference should also be made to D.O.T.'s "The Role of the Federal Government in Urban Transportation".

7.2 Belgium

The Government of Belgium formed a Regional Commission for the Improvement of Urban Transport in January 1962. Studies of all urban areas have been conducted and the government is now funding

the construction of subways in five cities. The first subway (called the Pre-Metro) was opened in Brussels in 1969.

7.3 Great Britain

The government has been subsidizing the nationalized railways for many years, some of the service of which are of an urban nature. It has also owned a large proportion of the urban bus operators that were not under municipal control, but required that their services be run at a profit. The 1968 Transport Act rationalized the government's involvement in transport with the following provisions:

- Subsidies on a line by line basis for rail services that are socially necessary,
- Options for local government to subsidize unprofitable rail or bus services in their area,
- Creation of a National Bus Company to combine all previous bus companies owned by the government along with the recently purchased British Electric Traction group,
- Creation of Passenger Transport Authorities to own and operate public transport in urban conurbations previously served by numerous municipal bus undertakings. These authorities will also take over traffic and transportation planning responsibilities for their area.
- A rebate on fuel tax to all bus operators,
- A 25% grant for the purchase of buses of an approved design,
- A 75% capital grant for public transport facilities.

7.4 Other Countries

There are obviously many other instances of national government's involvement in urban public transport. For example, the construction of the new Metro in Mexico City or the Rhine-Ruhr stadtbahn/subway network in Germany. A documentation of such activities is beyond the scope of this report.

7.5 United States of America

Limited Federal programs providing for loans and demonstrations were first authorized by the Housing Act of 1961. These programs were expanded and supplemented under the Urban Mass Transportation Act of 1964, for the first time permitting capital improvements to urban transit. In addition, the Act authorized the undertaking of research and development, and demonstration grants, in all phases of urban public transport. Grants were limited to two-thirds of the capital cost, with a limit of 12½% of the total appropriation per state, and applications were restricted to publicly-owned operators.

Amendments to the Act in September 1966 extended the grant program by authorizing annual expenditures of $150 million for the 1968 and 1969 fiscal years. They also created three new programs, under which grants could be made for technical studies, managerial training, and research and training in urban transportation problems.

These programs were originally administered by the Housing and Home Finance Administration and its successor HUD (Department

of Housing and Urban Development). The creation of the Department of Transport in April, 1967 provided a logical body to undertake this work, and an Urban Mass Transportation Administration was formed within D.O.T. with its own budget. During the fiscal year 1967, HUD funded 73 projects at a cost of $133.2 million. The UMTA program is budgeted below.

<u>Urban Mass Transportation Demonstration</u>

Fiscal Year	No. of Contracts	Amount
1965	12	$ 9,106,000
1966	9	5,800,000
1967	39	9,000,000
1968	28	8,300,000
1969	68	18,400,000
1970 (est)	--	30,000,000
1971 (est)	--	50,000,000

The UMTA 1969 R&D program can be broken down into:

Central City	$2,300,000
Major Activity Centres	710,000
Low Density Service	2,530,000
Commutation	3,500,000
Employment facilities	2,500,000
Equipment	4,850,000
Management and Operation	610,000
Planning and Program Analysis	1,500,000

A complete descriptive list of the UMTA program is available in the "Directory of Research Development and Demonstration". Similarly, the HUD New System project is documented in Tomorrows Transportation (32) in (59) and the list of reports on New Systems for Urban Transportation has been included in Section 4.1 of this report.

Although the U.S. Program has finally produced funds for substantial analysis, research and development in urban transport,

considerable criticism has been leveled at the uncoordinated nature of the program, and the use of so-called demonstration programs as a concealed subsidy to certain transit operators. A critical revue of the program is provided by George Smerk (57) (58), and by W.R. McGrath in an article appropriately titled to end this section "Urban Transport is an Urban Problem".

8. CONCLUSIONS

Comments and recommendations have been made throughout the body of this report and it remains to summarize the situation.

Urban transport in Canada as with most developed countries is dominated by the automobile almost to the point of strangulation. Public transport in Canada has survived the 1960's in remarkably good shape compared to its southern neighbour, but the debilitating spiral of increased costs and decreasing patronage has started and is likely to continue.

There are no technical or operational changes that will provide a panacea to these problems. Public transport cannot compete with the cost and convenience of the automobile, except for segregated transit (subways) in congested areas. The expansion of existing subway systems and the construction of new ones in certain areas should be given priority, even when such projects cannot be supported solely from revenue.

Transit in small cities will have to be heavily subsidized or abandoned. In larger cities, operations will tend toward increasing peak hour demand with a decreasing base service patronized principally by the young and the underprivileged minority. Usage by this latter group must surely justify increased subsidization of transit as a necessary social service. The trend to regional transit operation must be examined carefully as it may merely superimpose loss-making suburban services on a system already operating at a deficit. Cross subsidization of poor routes from the decreasing number of profitable routes has obviously reached its limit.

The basic transit fares are reaching levels which constitute a hardship to some users and a deterent to others. This suggests the need for more flexible fare structures. The greater use of zone fares and the possibility of peak hour surcharges should be examined, despite the considerable inherent difficulties. Reduced fares for senior citizens and students could be expanded to persons on welfare, but the transit operator should be fully compensated for all such concessions.

Transit vehicles deserve every assistance in combating delays due to congestion. Preference at traffic signals and the exclusive use of certain lanes are possibilities. However unpopular, certain restraints on automobile use in central areas may be necessary. Planning in anticipation of future problems is obviously preferable to planning in desperation. Now is the time to take a new look at transit - not as an anachronism but as a necessity for the survival of the central city. Balanced transportation is more than a cliché, it represents common sense and a more nearly optimum use of our transport resources, even when it must override personal (and often selfish) preferences. Help, whether from Municipal, Provincial or Federal Governments, is necessary to improve the lot of the five million Canadians who daily deposit their fares on transit vehicles. Help is needed soon, it is already too late for a few systems.

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